Defendants' Technology Tutorial

TQ Delta v. CommScope, Case No. 2:21-cv-310-JRG (lead)

TQ Delta v. Nokia, Case No. 2:21-cv-309-JRG (member)

Topics

- **Background of the Relevant Technology**
  - DSL Technology Generally
  - Forward Error Correction Coding
  - Interleaving
- **Background of the Asserted Patents**
  - Asserted Patents Overview
  - Families: 1, 2, 3, 4, 6, 9, 10

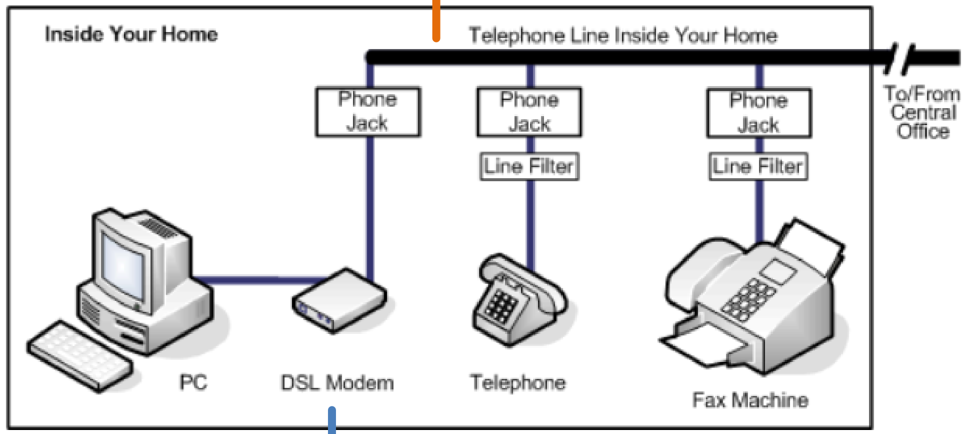
PART
01

An Introduction to the Relevant Technology

DSL Technology Generally

Telephone Lines
Uses twisted pair copper wire

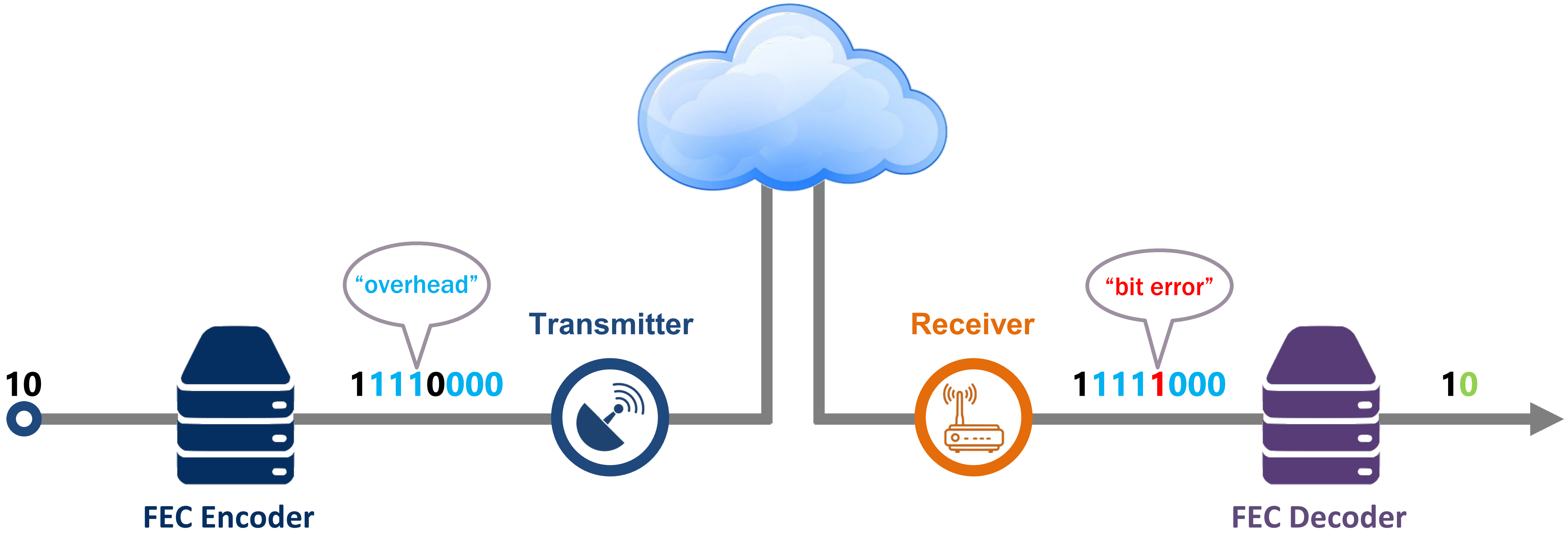
Discrete MultiTone
Uses multi-carrier modulation technique called DMT



DSL
Digital Subscriber Line

- DSL technology broadly describes a set of technologies for transmitting digital signals over copper telephone lines to the subscriber's premises.
- DSL was conceived of by the late 1980s to the early 1990s, and by the late 1980s development was well underway in industry and academia.
- Some of the most popular variants of DSL use a multi-carrier modulation technique called DMT (Discrete MultiTone).

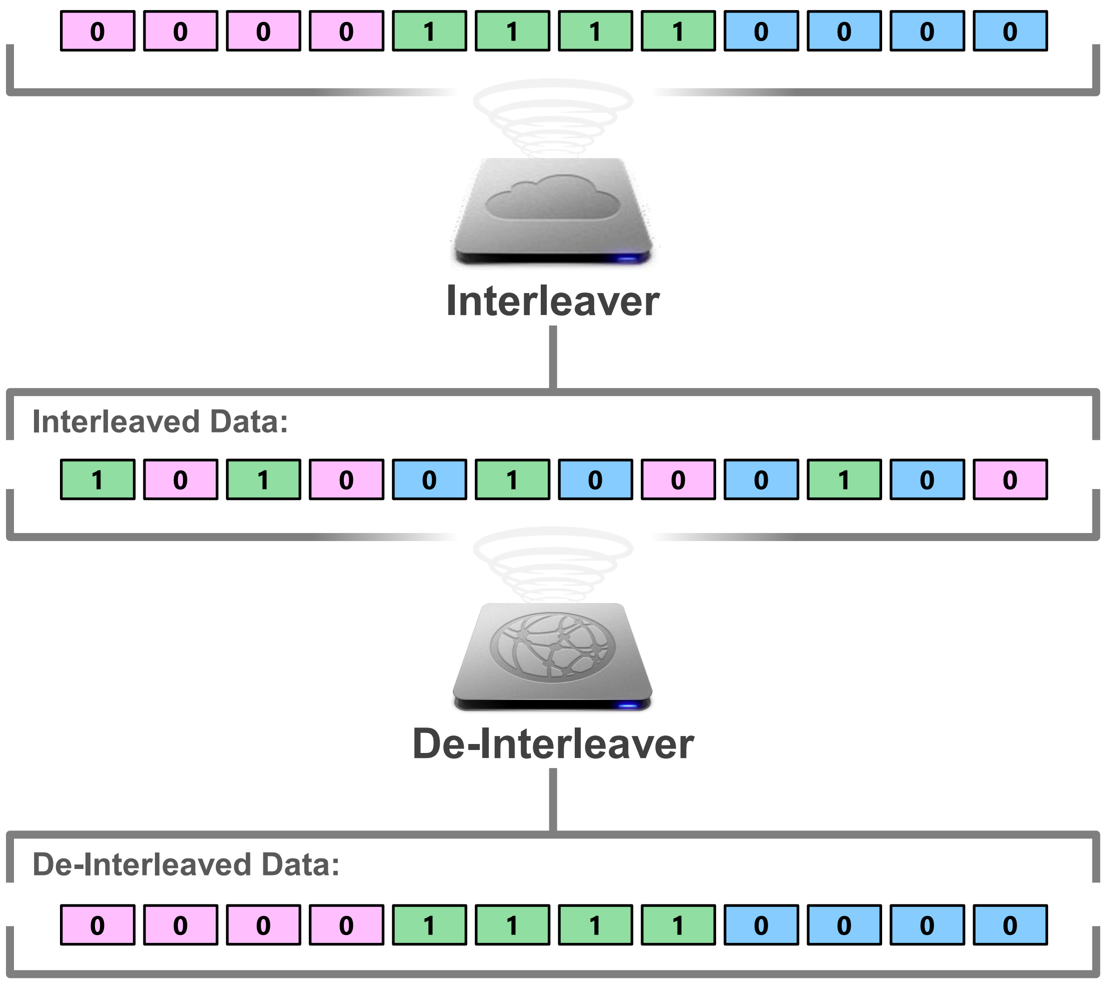
Forward Error Correction Coding



- One technology that is discussed in several of the Asserted Patents is error correction schemes, such as FEC encoding.
- FEC encoding involves the transmitter adding redundant information to the message being sent to the receiver, and the receiver then uses the redundant information to detect errors occurring in the message.

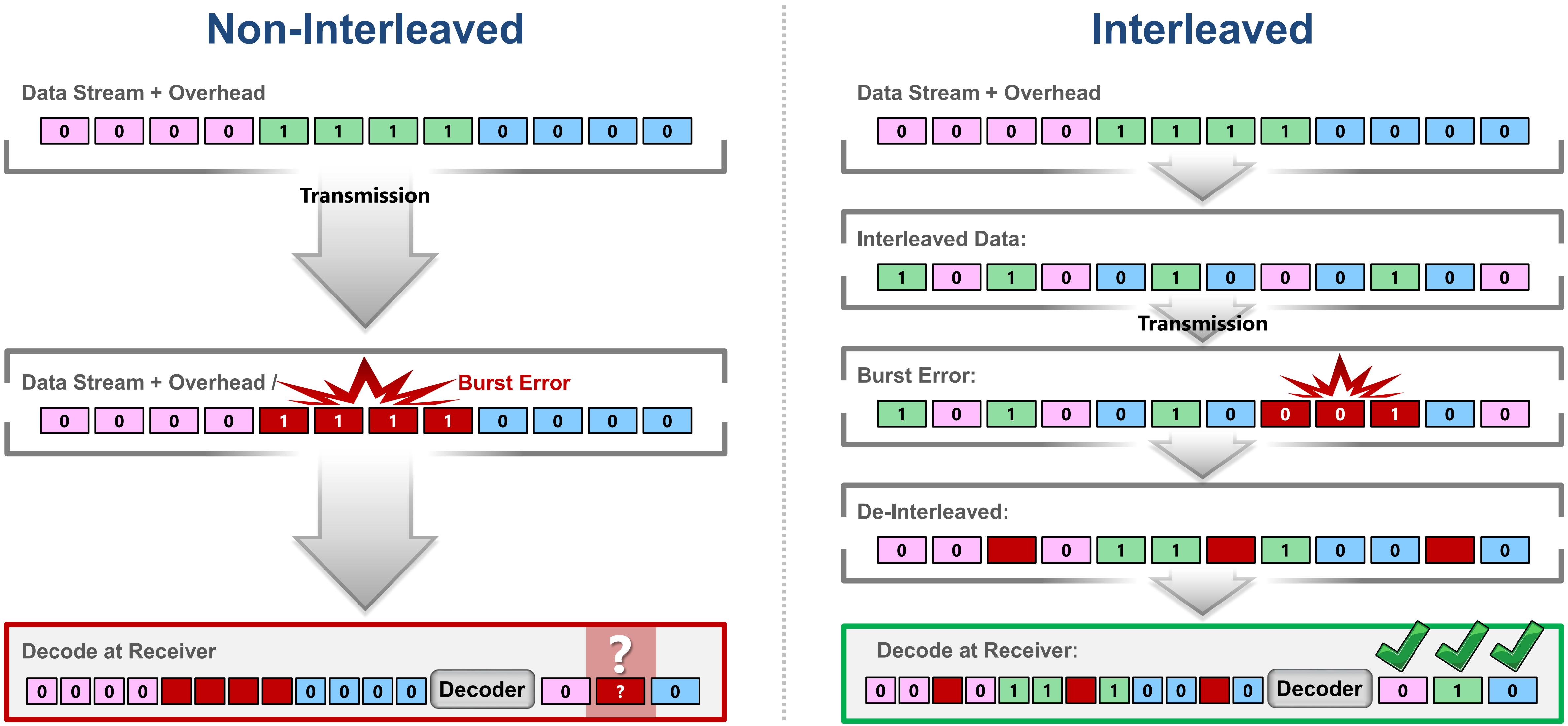
Interleaving

Data Stream + FEC Overhead



- Noise can corrupt bits of data communicated over the communication medium.
- There are many forms of noise, and one type is "impulse noise," which is intermittent and can randomly corrupt bits of serially transmitted data.
- When impulse noise occurs, the short, intermittent bursts can corrupt multiple groups of bits in a single data block if the groups of bits are transmitted sequentially.
- Interleaving can be used to address impulse noise. Interleaving shuffles data elements in a known way before transmission such that adjacent data elements are transmitted non-sequentially and spread out over a time interval.

Interleaved Data + Burst Errors



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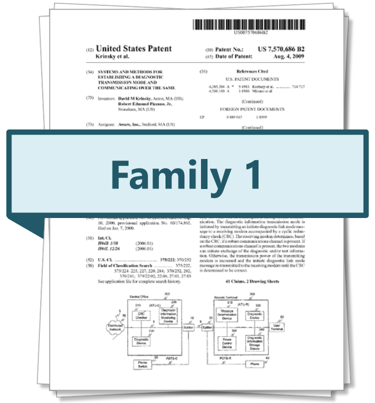
PART
02

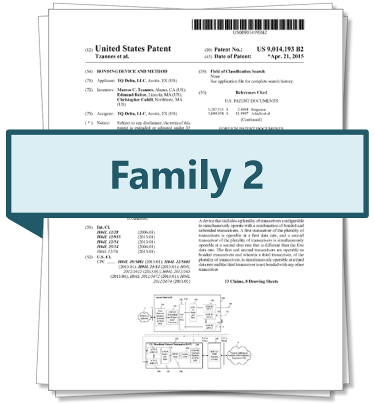
Background of the Asserted Patents

Background of the Patents



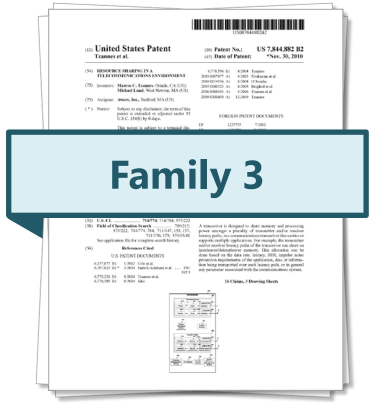
Family 1

Diagnostic Information



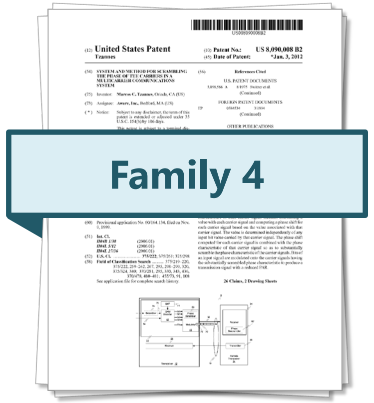
Family 2

Bonding



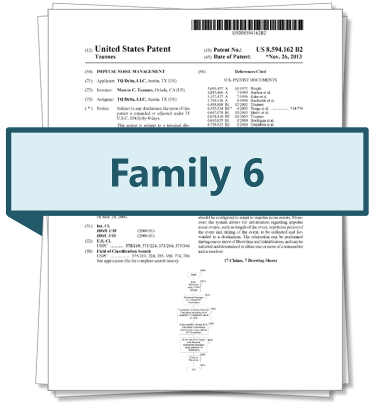
Family 3

Resource Sharing



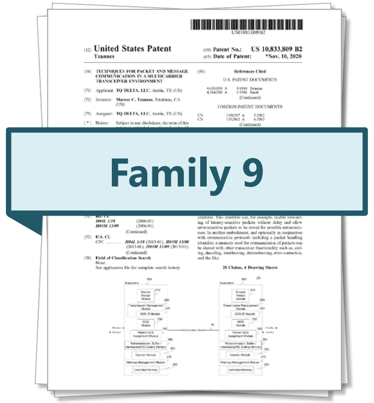
Family 4

Phase Scrambling



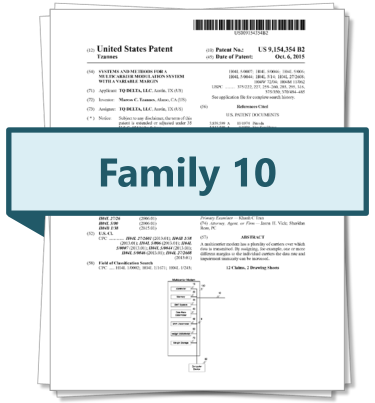
Family 6

Impulse Noise Management



Family 9

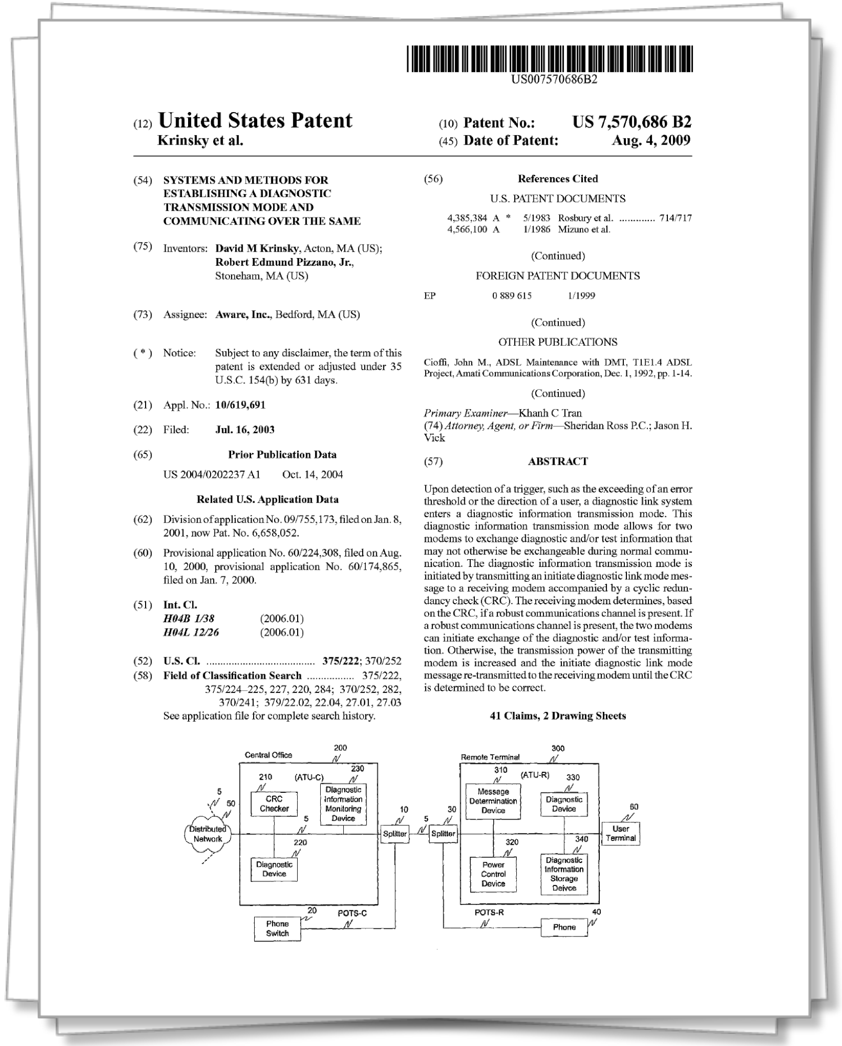
Packet Retransmission



Family 10

Variable Margin

Family 1 – Diagnostic Message Patent



US007570686B2

(12) United States Patent
Krinsky et al.

(10) Patent No.: US 7,570,686 B2
(45) Date of Patent: Aug. 4, 2009

(54) SYSTEMS AND METHODS FOR ESTABLISHING A DIAGNOSTIC TRANSMISSION MODE AND COMMUNICATING OVER THE SAME

(75) Inventors: **David M Krinsky**, Acton, MA (US); **Robert Edmund Pizzano, Jr.**, Stoneham, MA (US)

(73) Assignee: **Aware, Inc.**, Bedford, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 631 days.

(21) Appl. No.: **10/619,691**

(22) Filed: **Jul. 16, 2003**

(65) **Prior Publication Data**

US 2004/0202237 A1 Oct. 14, 2004

Related U.S. Application Data

(62) Division of application No. 09/755,173, filed on Jan. 8, 2001, now Pat. No. 6,658,052.

(60) Provisional application No. 60/224,308, filed on Aug. 10, 2000, provisional application No. 60/174,865, filed on Jan. 7, 2000.

(51) **Int. Cl.**
H04B 1/38 (2006.01)
H04L 12/26 (2006.01)

(52) **U.S. Cl.** **375/222**; 370/252

(58) **Field of Classification Search** 375/222, 375/224–225, 227, 220, 284; 370/252, 282, 370/241; 379/22.02, 22.04, 27.01, 27.03
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,385,384 A * 5/1983 Rosbury et al. 714/717
4,566,100 A 1/1986 Mizuno et al.

(Continued)

FOREIGN PATENT DOCUMENTS

EP 0 889 615 1/1999

(Continued)

OTHER PUBLICATIONS

Cioffi, John M., ADSL Maintenance with DMT, T1E1.4 ADSL Project, Amati Communications Corporation, Dec. 1, 1992, pp. 1-14.

(Continued)

Primary Examiner—Khanh C Tran
(74) *Attorney, Agent, or Firm*—Sheridan Ross P.C.; Jason H. Vick

(57) **ABSTRACT**

Upon detection of a trigger, such as the exceeding of an error threshold or the direction of a user, a diagnostic link system enters a diagnostic information transmission mode. This diagnostic information transmission mode allows for two modems to exchange diagnostic and/or test information that may not otherwise be exchangeable during normal communication. The diagnostic information transmission mode is initiated by transmitting an initiate diagnostic link mode message to a receiving modem accompanied by a cyclic redundancy check (CRC). The receiving modem determines, based on the CRC, if a robust communications channel is present. If a robust communications channel is present, the two modems can initiate exchange of the diagnostic and/or test information. Otherwise, the transmission power of the transmitting modem is increased and the initiate diagnostic link mode message re-transmitted to the receiving modem until the CRC is determined to be correct.

41 Claims, 2 Drawing Sheets

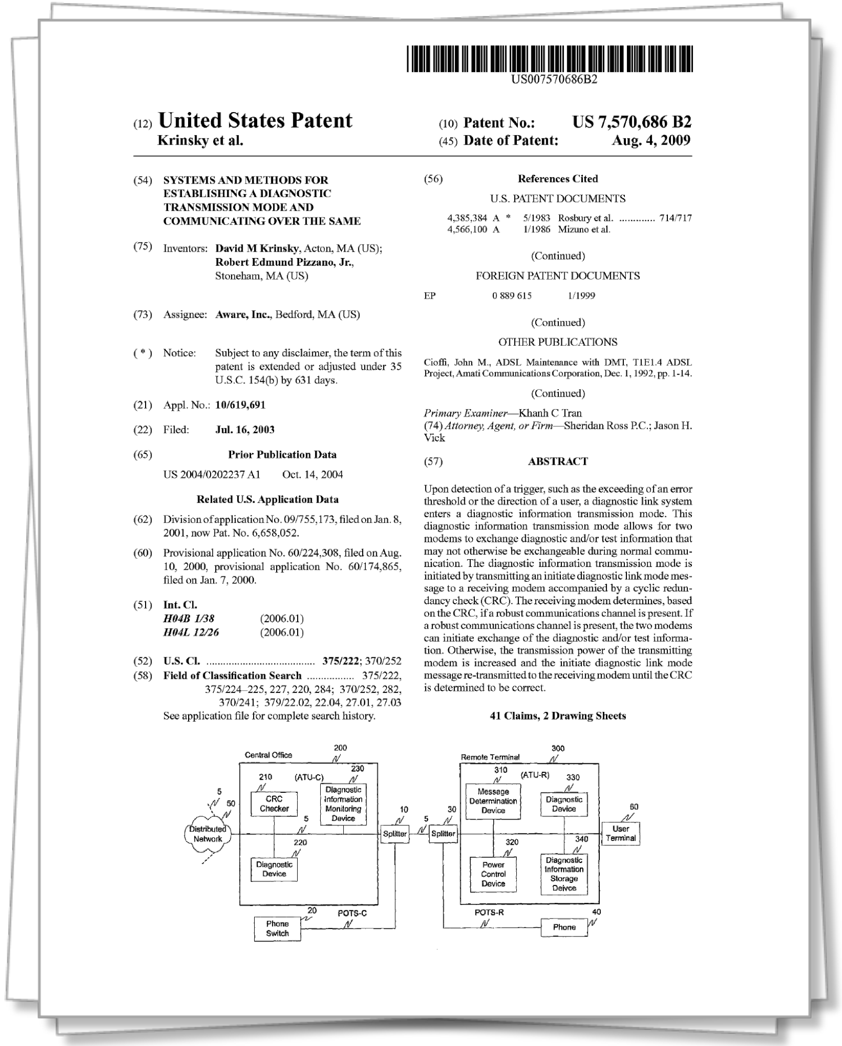
Title: Systems and methods for establishing a diagnostic transmission mode and communicating over the same

Inventors: David M. Krinsky & Robert Edmund Pizzano

Earliest Alleged Priority: January 7, 2000

Asserted Claims: 17, 18, 19, **36**, 37, 38, **40**

Alleged Problem


US007570686B2

(12) United States Patent
Krinsky et al.

(10) Patent No.: US 7,570,686 B2
(45) Date of Patent: Aug. 4, 2009

(54) SYSTEMS AND METHODS FOR ESTABLISHING A DIAGNOSTIC TRANSMISSION MODE AND COMMUNICATING OVER THE SAME

(75) Inventors: **David M Krinsky**, Acton, MA (US); **Robert Edmund Pizzano, Jr.**, Stoneham, MA (US)

(73) Assignee: **Aware, Inc.**, Bedford, MA (US)

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(52) **U.S. Cl.** **375/222**; 370/252

(58) **Field of Classification Search** 375/222, 375/224–225, 227, 220, 284; 370/252, 282, 370/241; 379/22.02, 22.04, 27.01, 27.03

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(Continued)

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EP 0 889 615 1/1999

(Continued)

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Cioffi, John M., ADSL Maintenance with DMT, T1E1.4 ADSL Project, Amati Communications Corporation, Dec. 1, 1992, pp. 1-14.

(Continued)

Primary Examiner—Khanh C Tran
(74) *Attorney, Agent, or Firm*—Sheridan Ross P.C.; Jason H. Vick

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Upon detection of a trigger, such as the exceeding of an error threshold or the direction of a user, a diagnostic link system enters a diagnostic information transmission mode. This diagnostic information transmission mode allows for two modems to exchange diagnostic and/or test information that may not otherwise be exchangeable during normal communication. The diagnostic information transmission mode is initiated by transmitting an initiate diagnostic link mode message to a receiving modem accompanied by a cyclic redundancy check (CRC). The receiving modem determines, based on the CRC, if a robust communications channel is present. If a robust communications channel is present, the two modems can initiate exchange of the diagnostic and/or test information. Otherwise, the transmission power of the transmitting modem is increased and the initiate diagnostic link mode message re-transmitted to the receiving modem until the CRC is determined to be correct.

41 Claims, 2 Drawing Sheets

In DSL technology, communications over a local subscriber loop between a central office and a subscriber premises is accomplished by modulating the data to be transmitted onto a multiplicity of discrete frequency carriers which are summed together and then transmitted over the subscriber loop. Individually, the carriers form discrete, non-overlapping communication subchannels of limited bandwidth. Collectively, the carriers form what is effectively a broadband communications channel. At the receiver end, the carriers are demodulated and the data recovered.

DSL systems experience disturbances from other data services on adjacent phone lines, such as, for example, ADSL, HDSL, ISDN, T1, or the like. These disturbances may commence after the subject ADSL service is already initiated and, since DSL for internet access is envisioned as an always-on service, the effect of these disturbances must be ameliorated by the subject ADSL transceiver.

- The ’686 patent considers disturbances or interference during data transmission in DSL systems.

’686 patent at 1:34-50.

Alleged Solution

US007570686B2

(12) **United States Patent**
Krinsky et al.

(10) **Patent No.: US 7,570,686 B2**
(45) **Date of Patent: Aug. 4, 2009**

(54) **SYSTEMS AND METHODS FOR ESTABLISHING A DIAGNOSTIC TRANSMISSION MODE AND COMMUNICATING OVER THE SAME**

(75) Inventors: **David M Krinsky**, Acton, MA (US); **Robert Edmund Pizzano, Jr.**, Stoneham, MA (US)

(73) Assignee: **Aware, Inc.**, Bedford, MA (US)

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(65) **Prior Publication Data**

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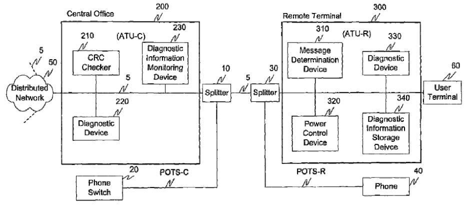


SUMMARY OF THE INVENTION

The systems and methods of this invention are directed toward reliably exchanging diagnostic and test information between transceivers over a digital subscriber line in the presence of voice communications and/or other disturbances. For simplicity of reference, the systems and methods of the invention will hereafter refer to the transceivers generically as modems. One such modem is typically located at a customer premises such as a home or business and is "downstream" from a central office with which it communicates. The other modem is typically located at the central office and is "upstream" from the customer premises. Consistent with industry practice, the modems are often referred to as "ATU-R" ("ADSL transceiver unit, remote," i.e., located at the customer premises) and "ATU-C" ("ADSL transceiver unit, central office" i.e., located at the central office). Each modem includes a transmitter section for transmitting data and a receiver section for receiving data, and is of the discrete multitone type, i.e., the modem transmits data over a multiplicity of subchannels of limited bandwidth. Typically, the upstream or ATU-C modem transmits data to the downstream or ATU-R modem over a first set of subchannels, which are usually the higher-frequency subchannels, and receives data from the downstream or ATU-R modem over a second, usually smaller, set of subchannels, commonly the lower-frequency subchannels. By establishing a diagnostic link mode between the two modems, the systems and methods of this invention are able to exchange diagnostic and test information in a simple and robust manner.

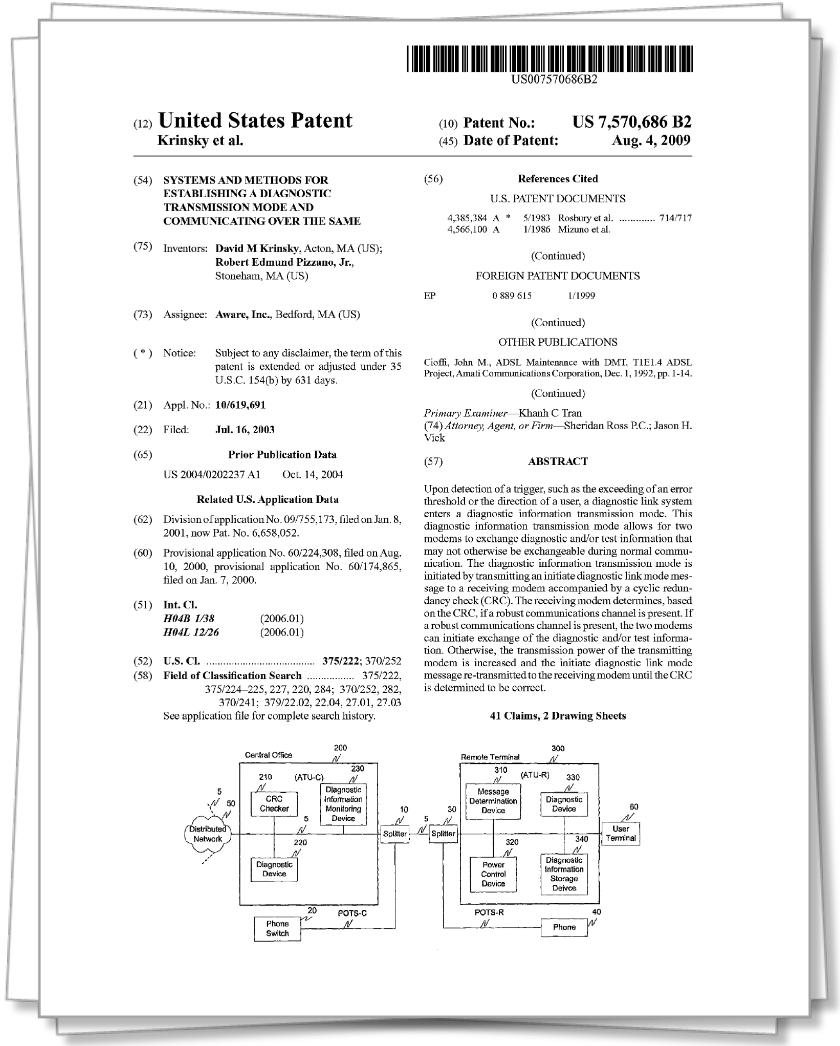
In the diagnostic link mode, the diagnostic and test information is communicated using a signaling mechanism that has a very high immunity to noise and/or other disturbances and can therefore operate effectively even in the case where the modems could not actually establish an acceptable connection in their normal operational mode.

For example, if the ATU-C and/or ATU-R modem fail to complete an initialization sequence, and are thus unable to enter a normal steady state communications mode, where the diagnostic and test information would normally be exchanged, the modems according to the systems and methods of this invention enter a robust diagnostic link mode. Alternatively, the diagnostic link mode can be entered automatically or manually, for example, at the direction of a user. In the robust diagnostic link mode, the modems exchange the diagnostic and test information that is, for example, used by a technician to determine the cause of a failure without the technician having to physically visit, i.e., a truckroll to, the remote site to collect data.

- Accordingly, the '686 patent is directed toward a system that can detect such disturbances.
- The system is intended to be a simple and robust method to identify problems and issues that are occurring on the transmission line, even where modems could not make a connection in the normal operational mode.
- The benefit of such a system is that it allows for problems and issues to be diagnosed without a technician having to physically visit a remote site to collect data.

'686 patent at 1:54-2:14, 2:15-34.

Alleged Solution



US007570686B2

(12) **United States Patent**
Krinsky et al.

(10) **Patent No.: US 7,570,686 B2**
(45) **Date of Patent: Aug. 4, 2009**

(54) **SYSTEMS AND METHODS FOR ESTABLISHING A DIAGNOSTIC TRANSMISSION MODE AND COMMUNICATING OVER THE SAME**

(75) Inventors: **David M Krinsky**, Acton, MA (US); **Robert Edmund Pizzano, Jr.**, Stoneham, MA (US)

(73) Assignee: **Aware, Inc.**, Bedford, MA (US)

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(21) Appl. No.: **10/619,691**

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(52) **U.S. Cl.** **375/222**; 370/252

(58) **Field of Classification Search** 375/222, 375/224–225, 227, 220, 284; 370/252, 282, 370/241; 379/22.02, 22.04, 27.01, 27.03
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(Continued)

Primary Examiner—Khanh C Tran
(74) *Attorney, Agent, or Firm*—Sheridan Ross P.C.; Jason H. Vick

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41 Claims, 2 Drawing Sheets

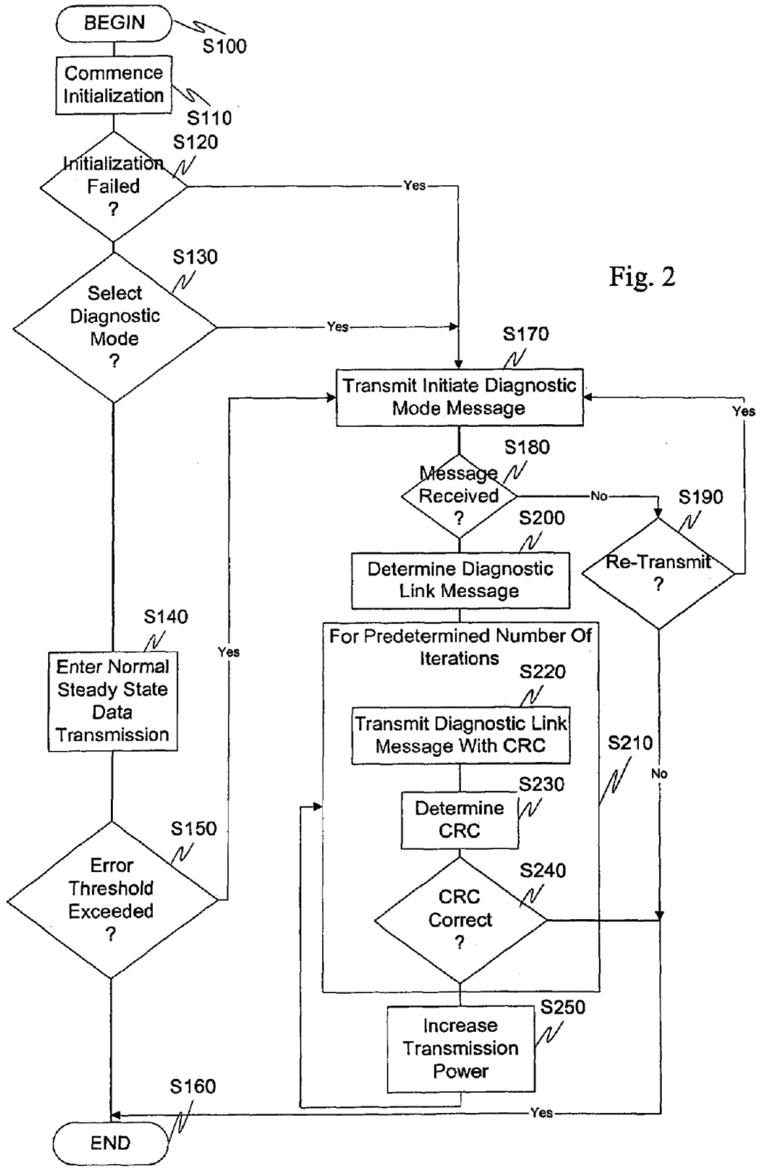
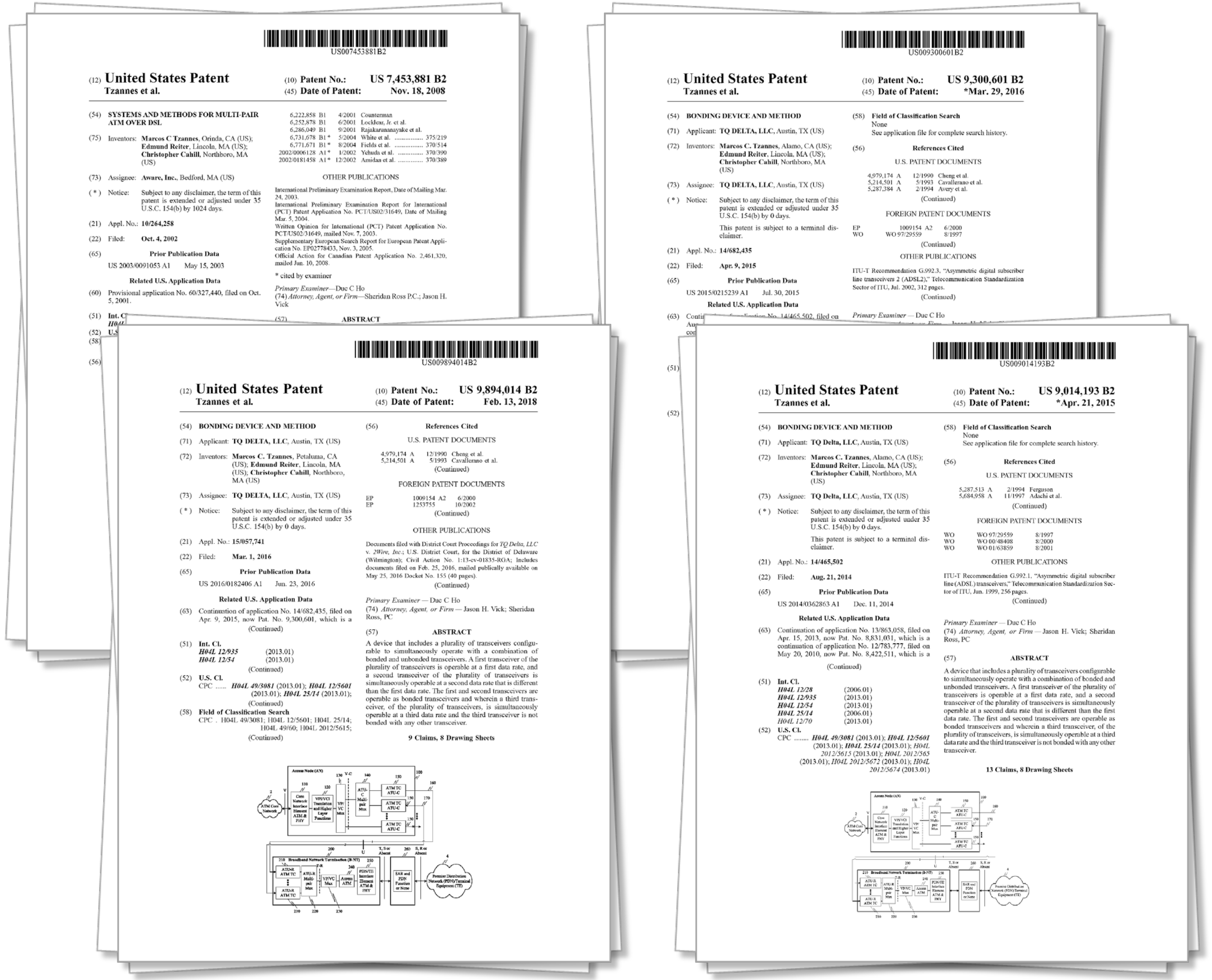


Fig. 2

- Figure 2 allows us to understand the basic steps of the functionality of the disclosed diagnostic mode.
- Starting at the top of the flow chart, the system commences initialization of its normal operational mode (S110). If the initialization fails (S120), diagnostic mode can either be selected manually or automatically (S130).
- Once diagnostic mode is initiated by the user device (S170) and received by the central office (S180), the system attempts to determine the diagnostic message (S200).
- In Step S210, the system repeatedly conveys the diagnostic information to ensure that the diagnostic message has been successfully communicated. In the event the message is not communicated, the system is coached to re-transmit (S190) or increase the transmission power (S250) as needed in order to convey the diagnostic message.

Family 2 – Bonding



Title: Systems and Methods for Multi-Pair ATM Over DSL and Bonding Device and Method

Inventors: Marcos C. Tzannes, Edmond Reiter, and Christopher Cahill

Earliest Alleged Priority: October 5, 2001

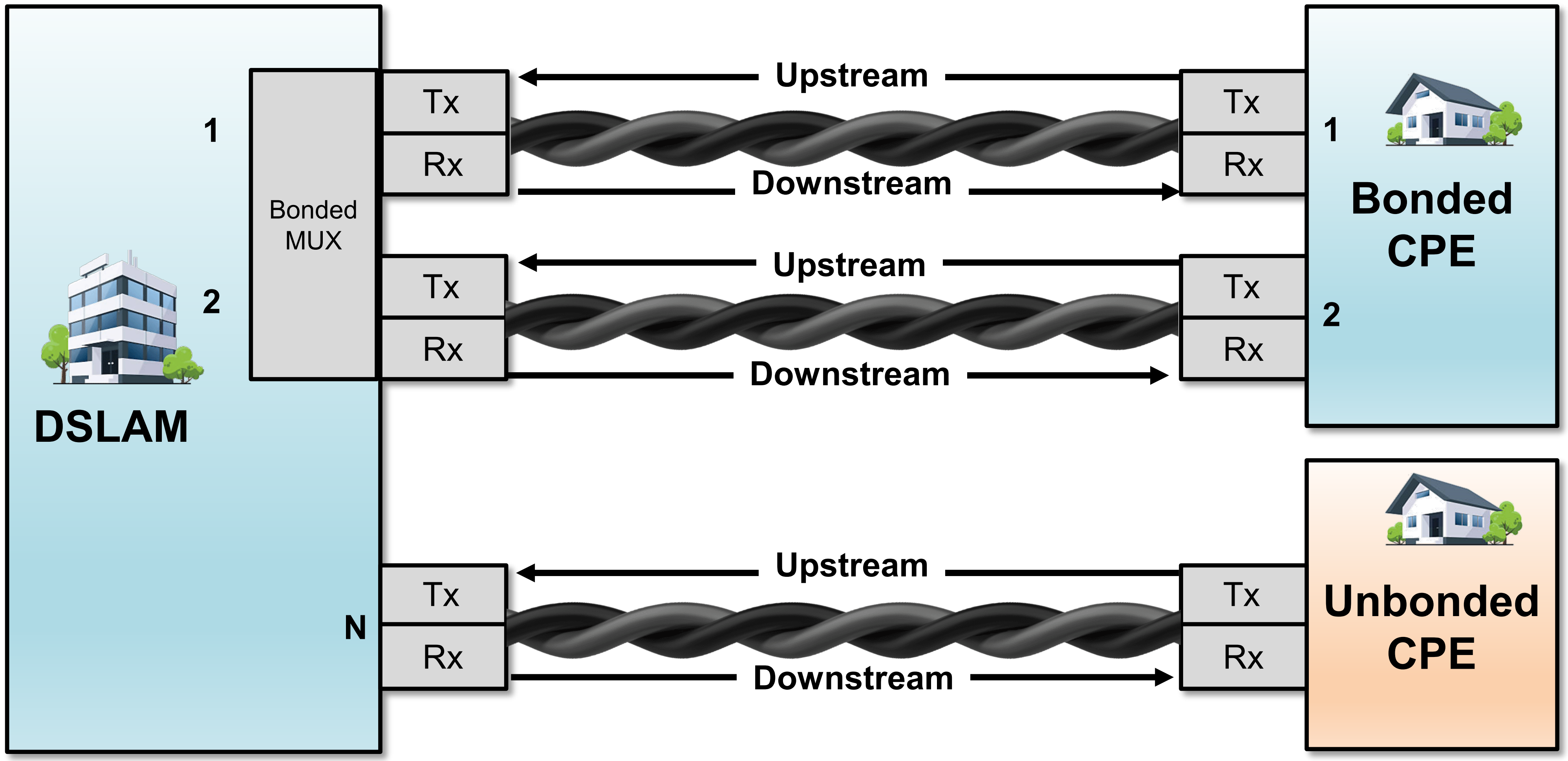
’881 Asserted Claims: 17, 18, 21, 23, **25,** 26, 29, 31, **33,** 34, **37,** and 38

’601 Asserted Claims: 8, 9, 13, 14, **15,** 16, 17, 18, & 21

’014 Asserted Claims: 8, & 3

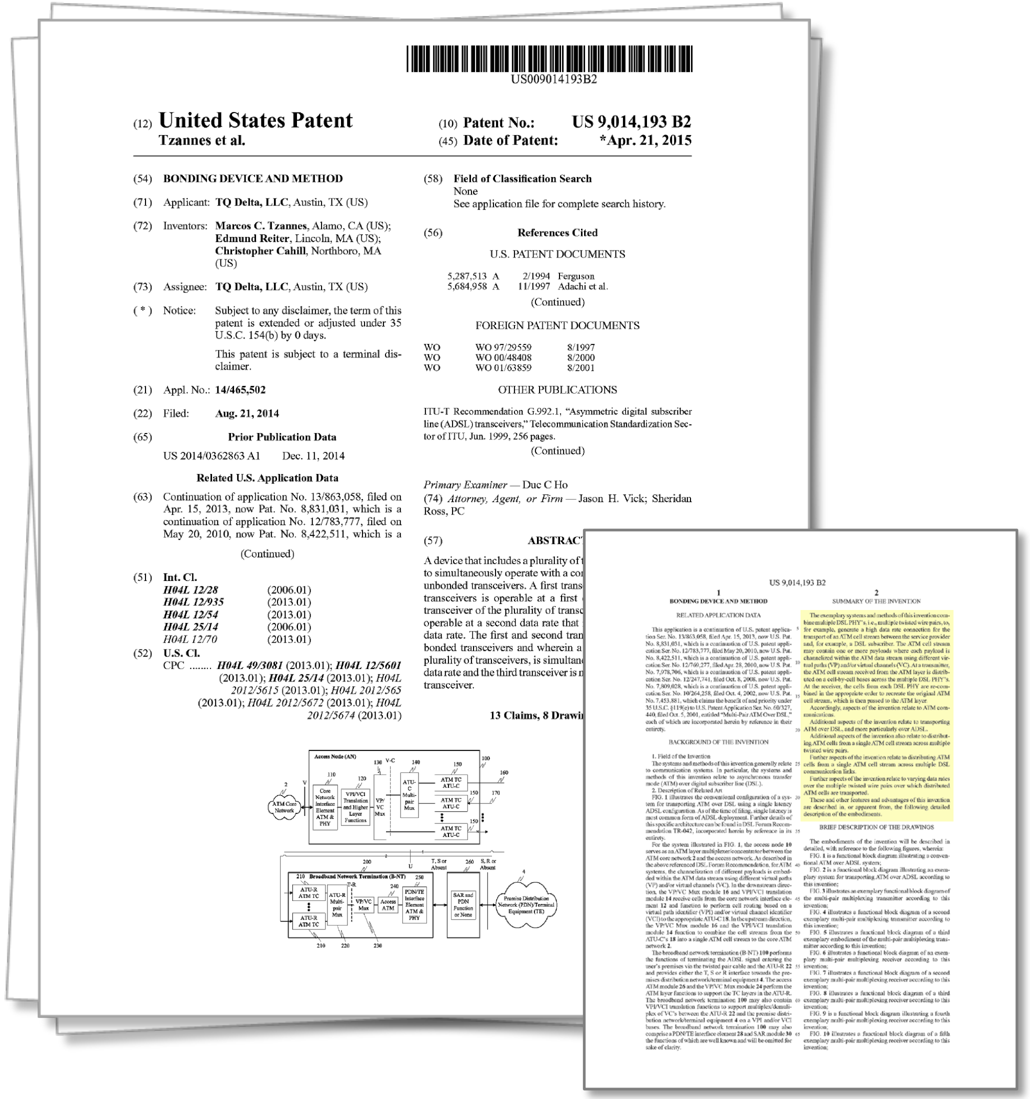
’193 Asserted Claims: 1, 9, 10, 11, 12, & 13

Bonded



- The Family 2 Patents consider what is called "bonded technology."
- In the 1970s, some houses would have multiple phone lines running into it. DSL uses or "bonds" these multiple lines together in order to increase speed and accuracy of transmitted information.
- The diagram shows this functionality. At the top of the diagram, you can see that two wires are running from the central office to a single home. When these lines are connected for transmitting information, they are referred to as a "bonded" line.
- Alternatively, at the bottom of the diagram, you see that there is a single twisted pair copper wire running from the central office to a different home. This is an "unbonded" line.

Alleged Invention


US009014193B2

(12) United States Patent
Tzannes et al.

(10) Patent No.: US 9,014,193 B2
(45) Date of Patent: *Apr. 21, 2015

(54) BONDING DEVICE AND METHOD

(71) Applicant: TQ Delta, LLC, Austin, TX (US)

(72) Inventors: Marcos C. Tzannes, Alamo, CA (US); Edmund Reiter, Lincoln, MA (US); Christopher Cahill, Northboro, MA (US)

(73) Assignee: TQ Delta, LLC, Austin, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.
This patent is subject to a terminal disclaimer.

(21) Appl. No.: 14/465,502

(22) Filed: Aug. 21, 2014

(65) Prior Publication Data
US 2014/0362863 A1 Dec. 11, 2014

Related U.S. Application Data

(63) Continuation of application No. 13/863,058, filed on Apr. 15, 2013, now Pat. No. 8,831,031, which is a continuation of application No. 12/783,777, filed on May 20, 2010, now Pat. No. 8,422,511, which is a
(Continued)

(58) Field of Classification Search
None
See application file for complete search history.

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WO WO 00/48408 8/2000
WO WO 01/63859 8/2001

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ITU-T Recommendation G.992.1, "Asymmetric digital subscriber line (ADSL) transceivers," Telecommunication Standardization Sector of ITU, Jun. 1999, 256 pages.
(Continued)

Primary Examiner — Duc C Ho
(74) Attorney, Agent, or Firm — Jason H. Vick; Sheridan Ross, PC

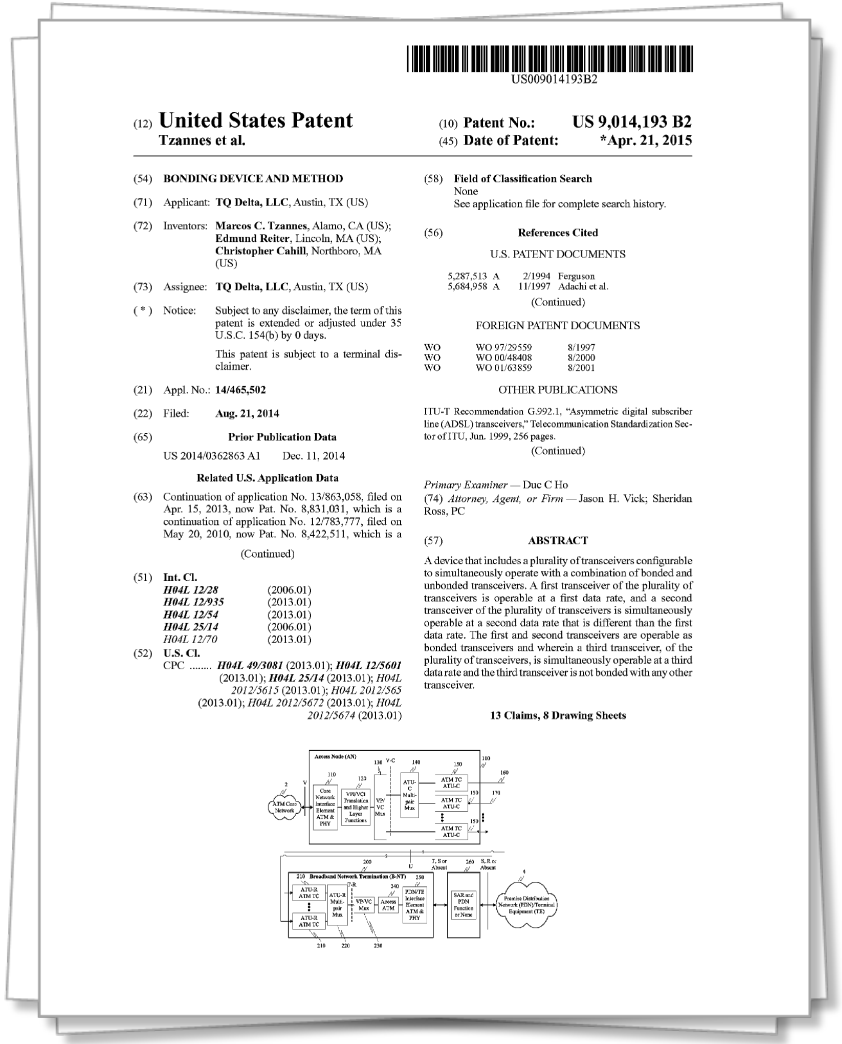
(57) ABSTRACT

13 Claims, 8 Drawing Sheets

> The exemplary systems and methods of this invention combine multiple DSL PHY's, i.e., multiple twisted wire pairs, to, for example, generate a high data rate connection for the transport of an ATM cell stream between the service provider and, for example, a DSL subscriber. The ATM cell stream may contain one or more payloads where each payload is channelized within the ATM data stream using different virtual paths (VP) and/or virtual channels (VC). At a transmitter, the ATM cell stream received from the ATM layer is distributed on a cell-by-cell bases across the multiple DSL PHY's. At the receiver, the cells from each DSL PHY are re-combined in the appropriate order to recreate the original ATM cell stream, which is then passed to the ATM layer.
>
> Accordingly, aspects of the invention relate to ATM communications.
>
> Additional aspects of the invention relate to transporting ATM over DSL, and more particularly over ADSL.
>
> Additional aspects of the invention also relate to distributing ATM cells from a single ATM cell stream across multiple twisted wire pairs.
>
> Further aspects of the invention relate to distributing ATM cells from a single ATM cell stream across multiple DSL communication links.
>
> Further aspects of the invention relate to varying data rates over the multiple twisted wire pairs over which distributed ATM cells are transported.
>
> These and other features and advantages of this invention are described in, or apparent from, the following detailed description of the embodiments.

- The Family 2 Patents consider a communication system with:
  - Multiple twisted pair wires
  - Multiple DSL communication links
  - Varying data rates
  - Reduced latency
- With the goal of:
  - Improved data transmission speed between the provider and subscriber

Latency



US009014193B2

(12) **United States Patent**
Tzannes et al.

(10) **Patent No.:** **US 9,014,193 B2**
(45) **Date of Patent:** ***Apr. 21, 2015**

(54) **BONDING DEVICE AND METHOD**

(71) Applicant: **TQ Delta, LLC**, Austin, TX (US)

(72) Inventors: **Marcos C. Tzannes**, Alamo, CA (US); **Edmund Reiter**, Lincoln, MA (US); **Christopher Cahill**, Northboro, MA (US)

(73) Assignee: **TQ Delta, LLC**, Austin, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/465,502**

(22) Filed: **Aug. 21, 2014**

(65) **Prior Publication Data**

US 2014/0362863 A1 Dec. 11, 2014

Related U.S. Application Data

(63) Continuation of application No. 13/863,058, filed on Apr. 15, 2013, now Pat. No. 8,831,031, which is a continuation of application No. 12/783,777, filed on May 20, 2010, now Pat. No. 8,422,511, which is a

(Continued)

(51) **Int. Cl.**
H04L 12/28 (2006.01)
H04L 12/935 (2013.01)
H04L 12/54 (2013.01)
H04L 25/14 (2006.01)
H04L 12/70 (2013.01)

(52) **U.S. Cl.**
CPC ***H04L 49/3081*** (2013.01); ***H04L 12/5601*** (2013.01); ***H04L 25/14*** (2013.01); *H04L 2012/5615* (2013.01); *H04L 2012/565* (2013.01); *H04L 2012/5672* (2013.01); *H04L 2012/5674* (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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ITU-T Recommendation G.992.1, "Asymmetric digital subscriber line (ADSL) transceivers," Telecommunication Standardization Sector of ITU, Jun. 1999, 256 pages.

(Continued)

Primary Examiner — Duc C Ho
(74) *Attorney, Agent, or Firm* — Jason H. Vick; Sheridan Ross, PC

(57) **ABSTRACT**

A device that includes a plurality of transceivers configurable to simultaneously operate with a combination of bonded and unbonded transceivers. A first transceiver of the plurality of transceivers is operable at a first data rate, and a second transceiver of the plurality of transceivers is simultaneously operable at a second data rate that is different than the first data rate. The first and second transceivers are operable as bonded transceivers and wherein a third transceiver, of the plurality of transceivers, is simultaneously operable at a third data rate and the third transceiver is not bonded with any other transceiver.

13 Claims, 8 Drawing Sheets

Furthermore, an in addition to the changes in data rate that are possible on the DSL PHYs, ATM cells transported over a DSL PHY can have different end-to-end delay (latency) based on several parameters. This potential latency difference between bonded PHYs places implementation requirements on the multi-pair multiplexer. In particular, the multi-pair multiplexer receiver must be able to reconstruct the ATM stream even if the ATM cells are not being received in the same order as they where transmitted.

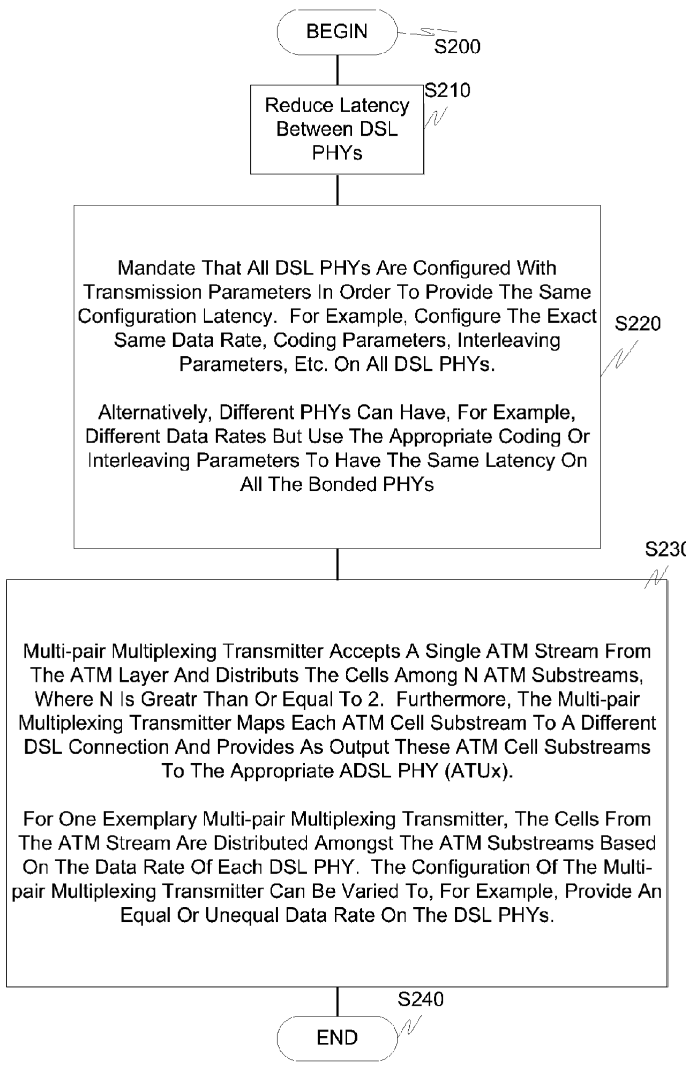
For example, some of the exemplary reasons for having different delays over different DSL PHYs include, but are not limited, configuration latency which is based on the configuration of the DSL transmission parameters. Specifically, these parameters include the data rate, coding parameters, such as the coding method, codeword size, interleaving parameters, framing parameters, or the like.

ATM-TC latency is based on cell rate decoupling in the ATM-TC. Specifically, the ATM-TC block in ADSL transceivers performs cell rate decoupling by inserting idle cells according to the ITU Standard I.432, incorporated herein by reference in its entirety. This means that depending on the ATU timing and the state of the ATU buffers, an ATM cell that is sent over a DSL PHY will experience non-constant end-to-end delay (latency) through the PHY.

Wire latency is based on differences in the twisted wire pairs. Specifically, the DSL electrical signals can experience different delays based on the difference in length of the wire, the gauge of the wire, the number bridged taps, or the like.

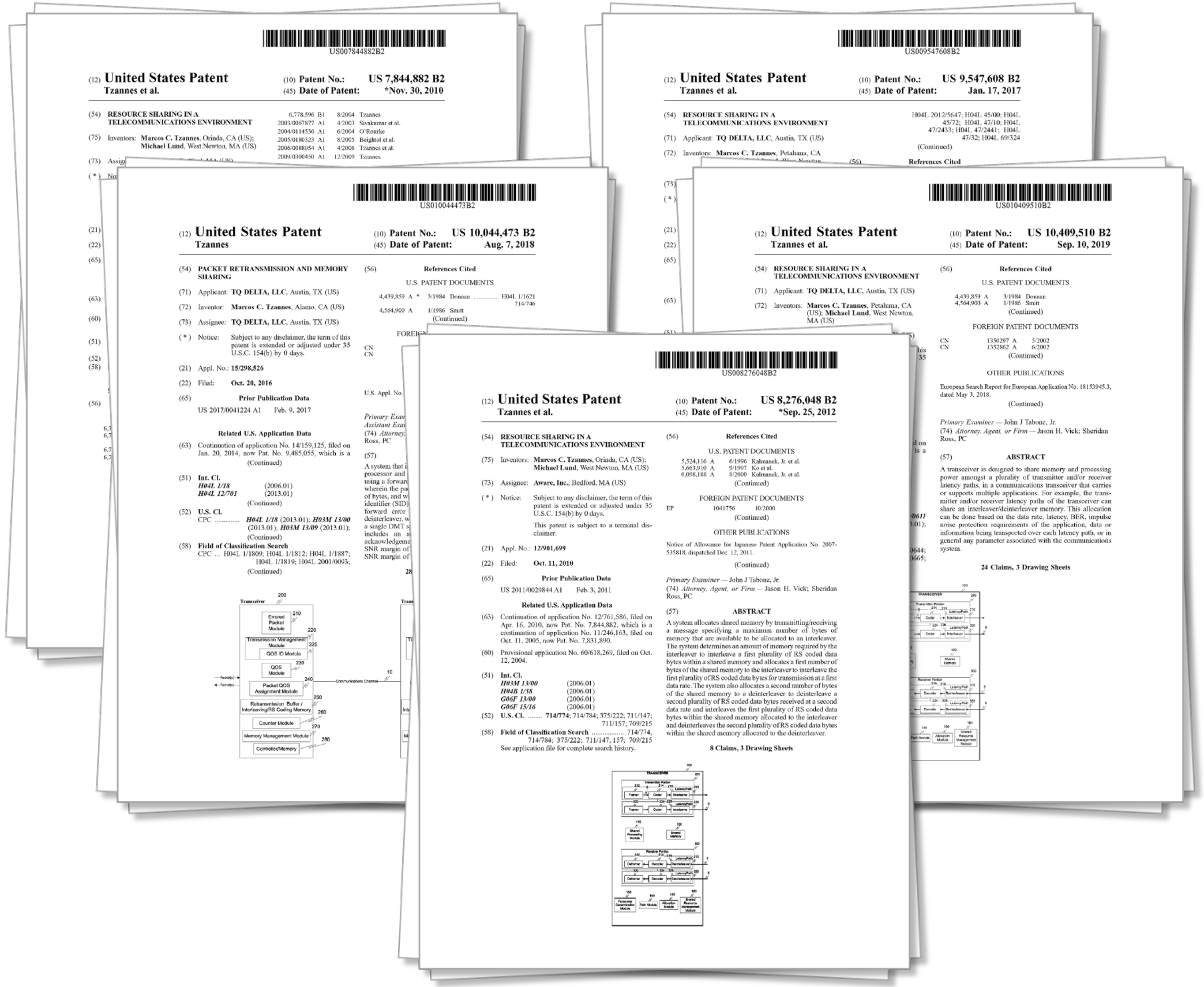
Design latency is based on differences in the DSL PHY design. Specifically, the latency of the PHY can also depend on the design chosen by the manufacture.

Thus, as result of the different latencies in the PHYs, it is possible that an ATM cell that was sent over a DSL PHY may be received at the multi-pair multiplexing receiver after an ATM cell that was sent out later on a different DSL PHY.



- The Family 2 patents identify a number of types of "latency" that can impact or slow down the transmission of data.
- These types of "latency" include configuration latency, ATM-TC latency, wire latency, and design latency.
- The patents generally indicate that a goal of the patent is to reduce the difference in such latency between two bonded lines.

Family 3 – Resource Sharing



Title: Resource sharing in a telecommunications environment

Inventors: Marcos C. Tzannes & Michael Lund

Earliest Alleged Priority: October 12, 2004

’882 Asserted Claims: 9, 13, 14, 15

’048 Asserted Claims: 1, 5, 6, 7

’5473 Asserted Claims: 10, 28, 36

’608 Asserted Claims: 2, 3, 4

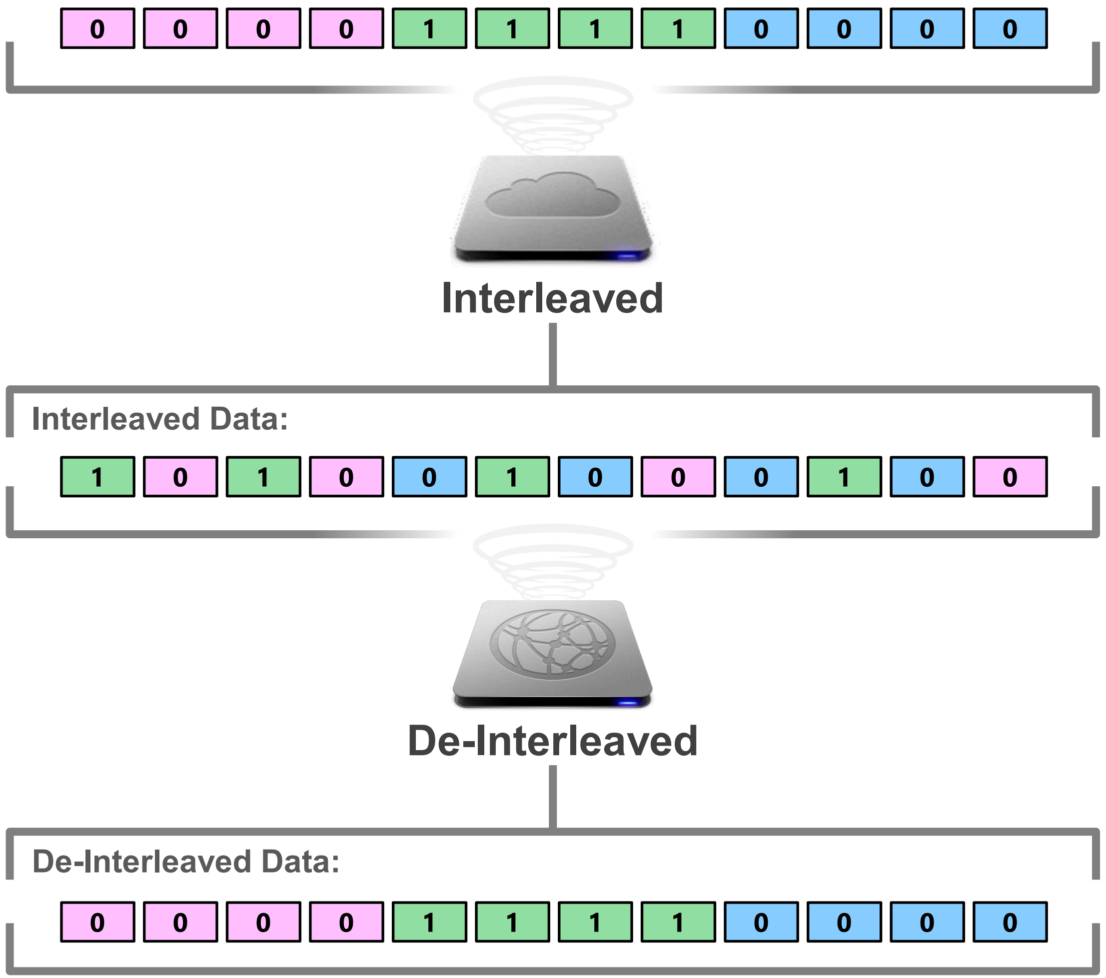
’510 Asserted Claims: 21, 22, 23

Alleged Problem

One difficulty with implementing multiple latency paths in a transceiver is the fact that a latency path is a complicated digital circuit that requires a large amount of memory and processing power. An interleaver within a latency path can consume a large amount of memory in order to provide error correcting capability. For example, a typical DSL transceiver will have at least one latency path with approximately 16 kbytes of memory for the interleaver. Likewise, the coding block, for example, a Reed Solomon coder, consumes a large amount of processing power. In general, as the number of latency paths increase, the memory and processing power requirements for a communication system become larger.

Accordingly, an exemplary aspect of this invention relates to sharing memory between one or more interleavers and/or deinterleavers in a transceiver. More particularly, an exemplary aspect of this invention relates to shared latency path memory in a transceiver.

Data Stream + FEC Overhead



- The Family 3 Patents describe using interleaving and Reed-Solomon encoding to reduce errors in transmission.
- These methodologies, however, require a large amount of memory to implement.

Alleged Solution

One difficulty with implementing multiple latency paths in a transceiver is the fact that a latency path is a complicated digital circuit that requires a large amount of memory and processing power. An interleaver within a latency path can consume a large amount of memory in order to provide error correcting capability. For example, a typical DSL transceiver will have at least one latency path with approximately 16 kbytes of memory for the interleaver. Likewise, the coding block, for example, a Reed Solomon coder, consumes a large amount of processing power. In general, as the number of latency paths increase, the memory and processing power requirements for a communication system become larger.

Accordingly, an exemplary aspect of this invention relates to sharing memory between one or more interleavers and/or deinterleavers in a transceiver. More particularly, an exemplary aspect of this invention relates to shared latency path memory in a transceiver.

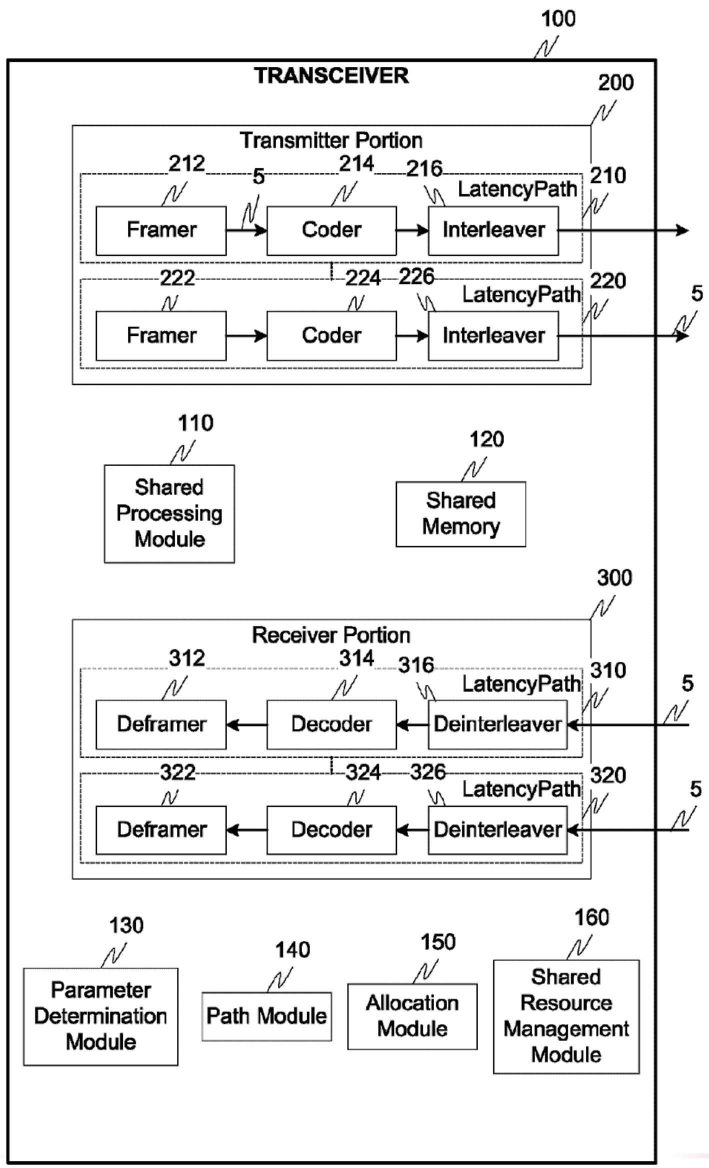
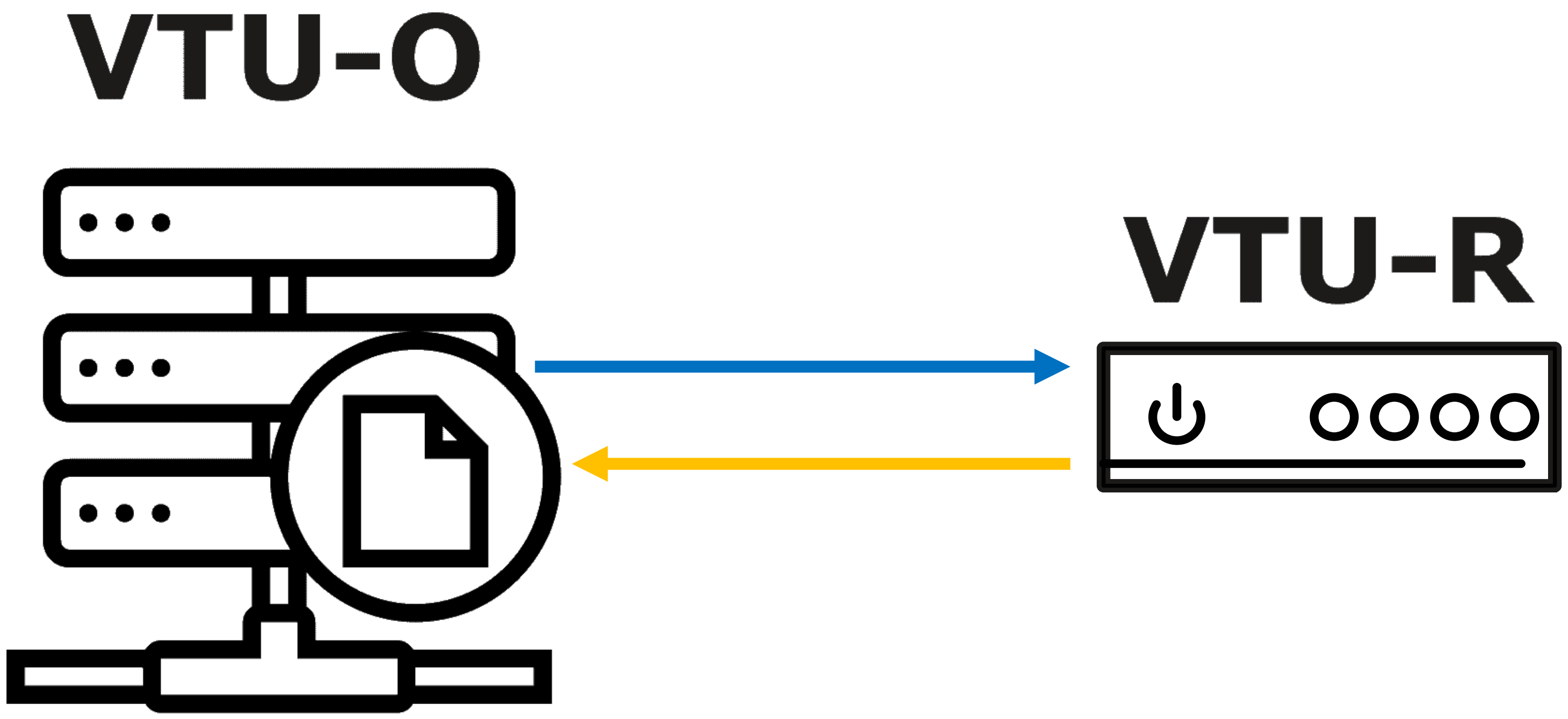


Fig. 1

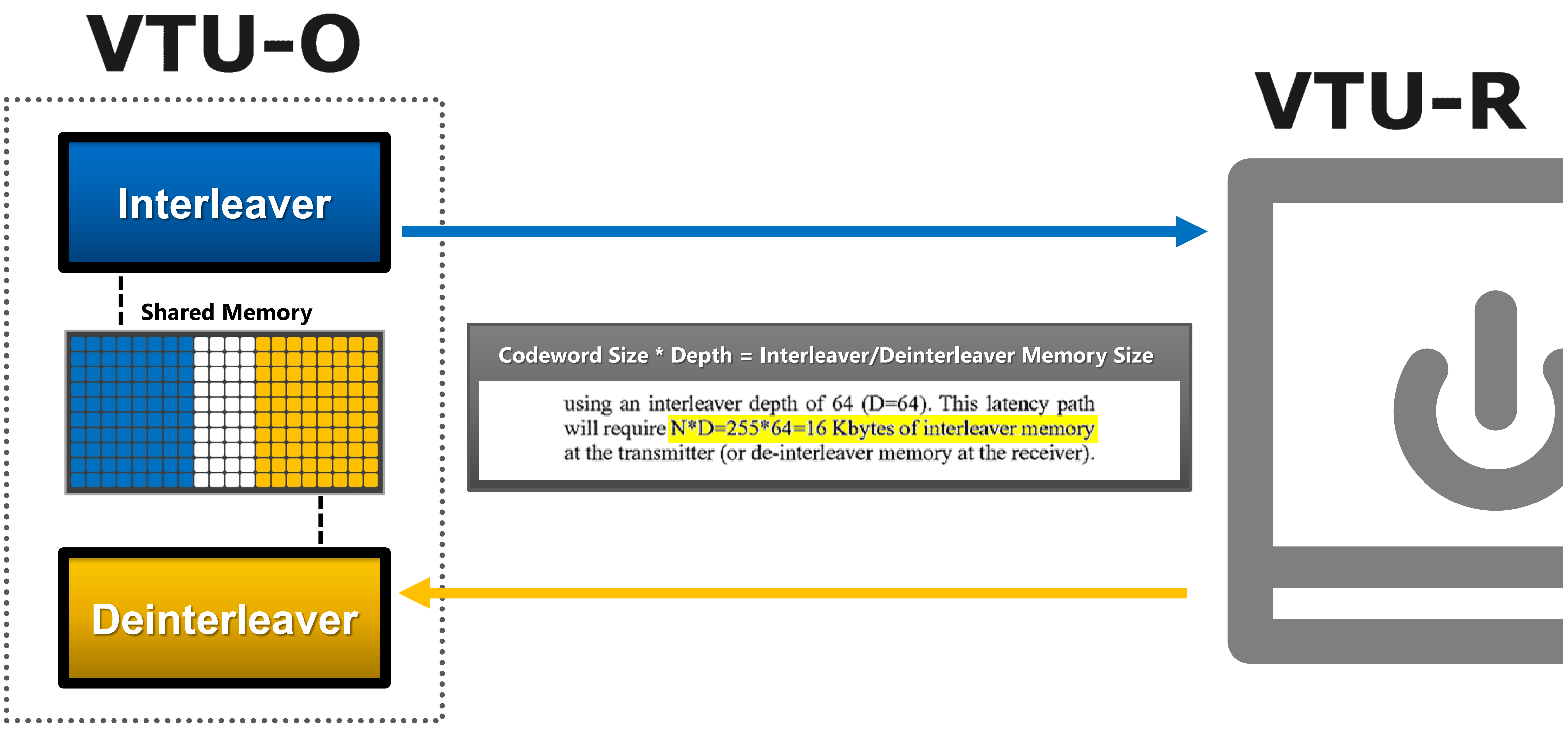
- The Family 3 Patents contemplate sharing memory between the interleaver and deinterleaver in a transceiver.

Initialization



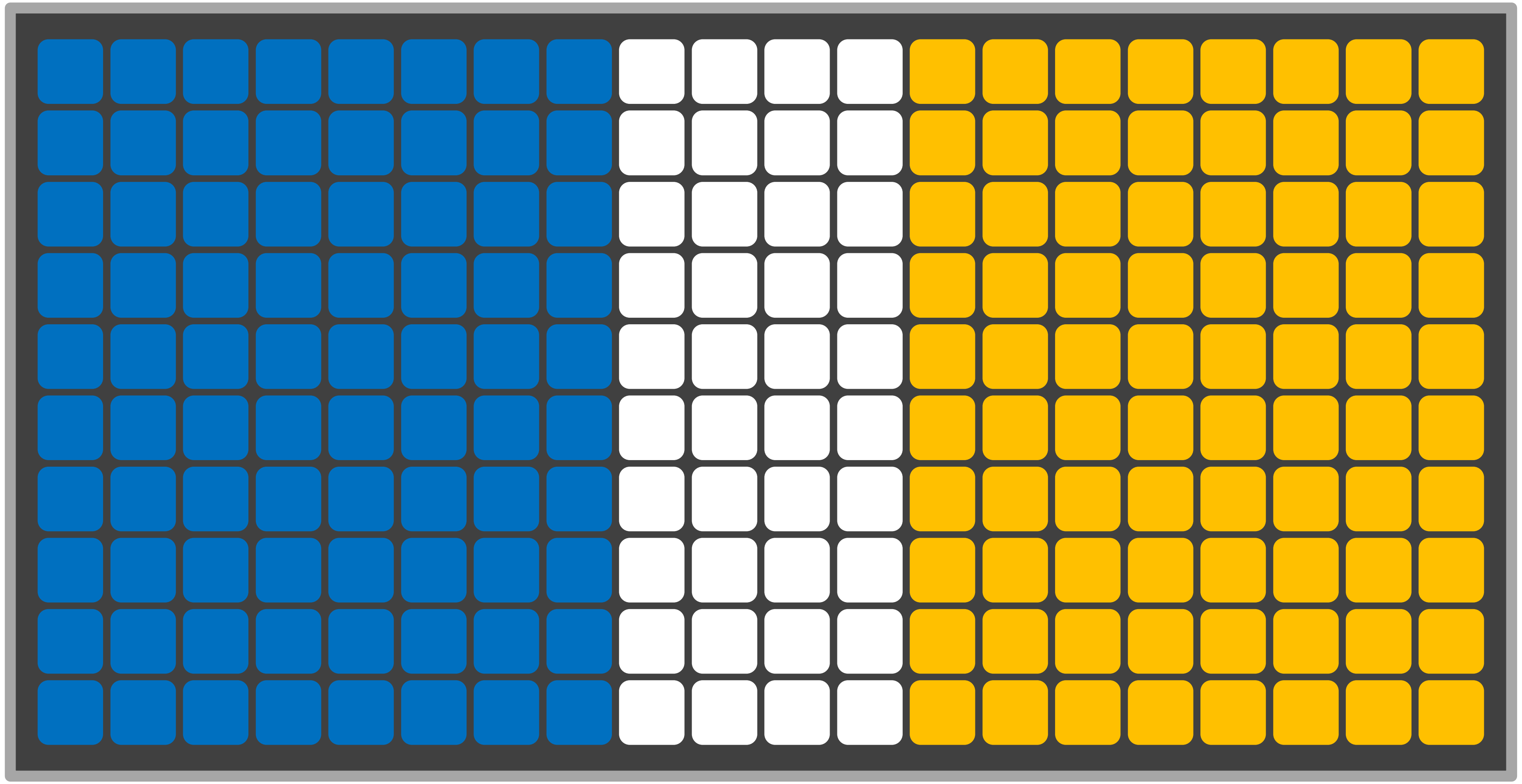
- During initialization, the VDSL Transceiver Unit at the Office (VTU-O) and VDSL Transceiver Unit at the Remote (VTU-R) communicate.
- The VTU-O and VTU-R measure the characteristics of the channel and agree on a contract that defines the communication link.

Memory Allocation in a Transceiver



- The allocation of memory between the interleaver and deinterleaver may be done using various implementations.
- The Family 3 Patents use the implementation N*D.
- In a symmetric service, the interleaver and deinterleaver memory sizes would be equal.
- In an asymmetric service, the interleaver and deinterleaver memory sizes would be different.

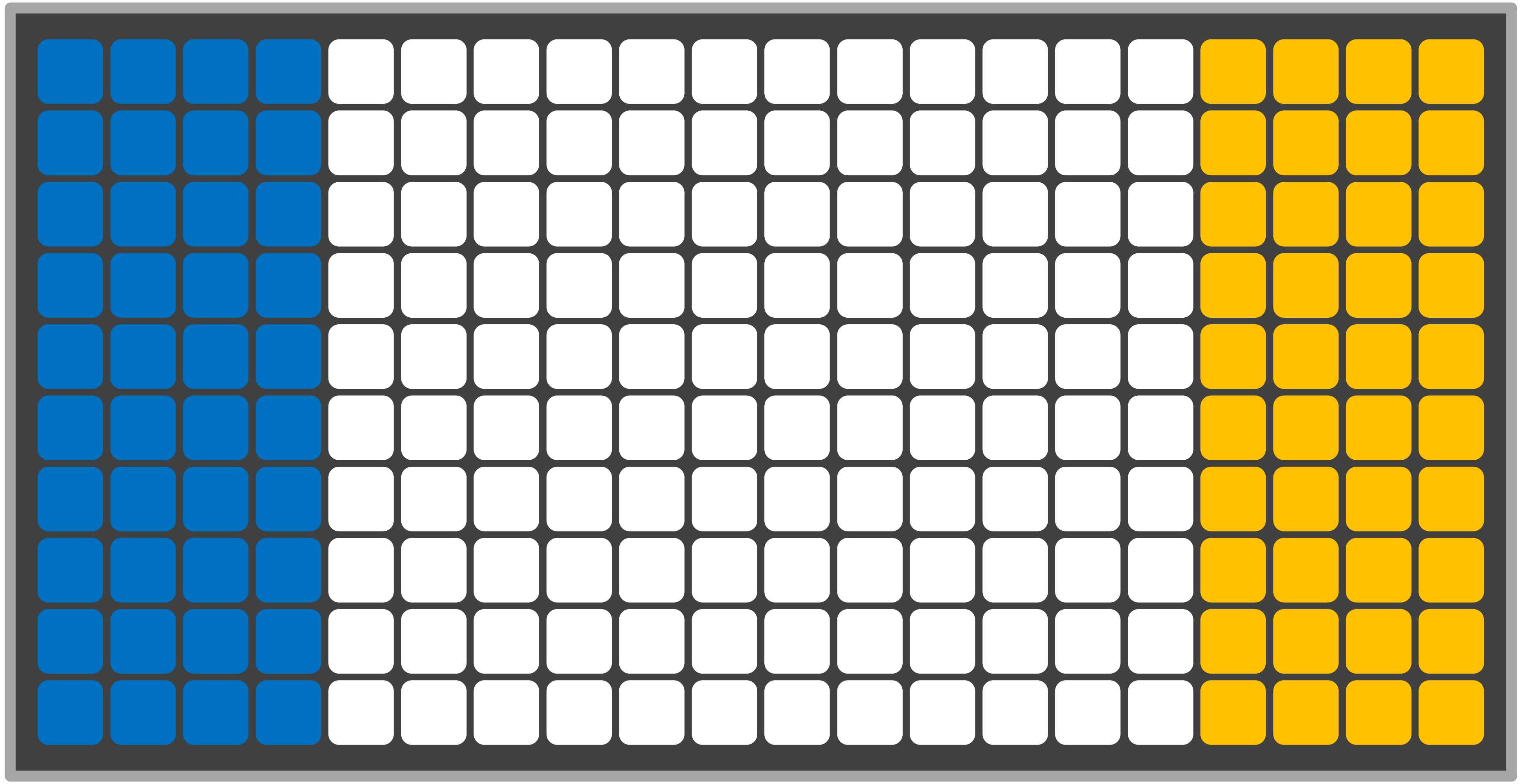
Shared Memory at the VTU-O



Each Square = 100 bytes | Interleaver Memory | Unused Memory | Deinterleaver Memory

- In this implementation, the following parameters were applied:
- RAM size = 20 Kbytes
- Symmetric Service
- **Interleaver/deinterleaver memory = N*D; N=128 bytes per codeword; D=64 codewords**

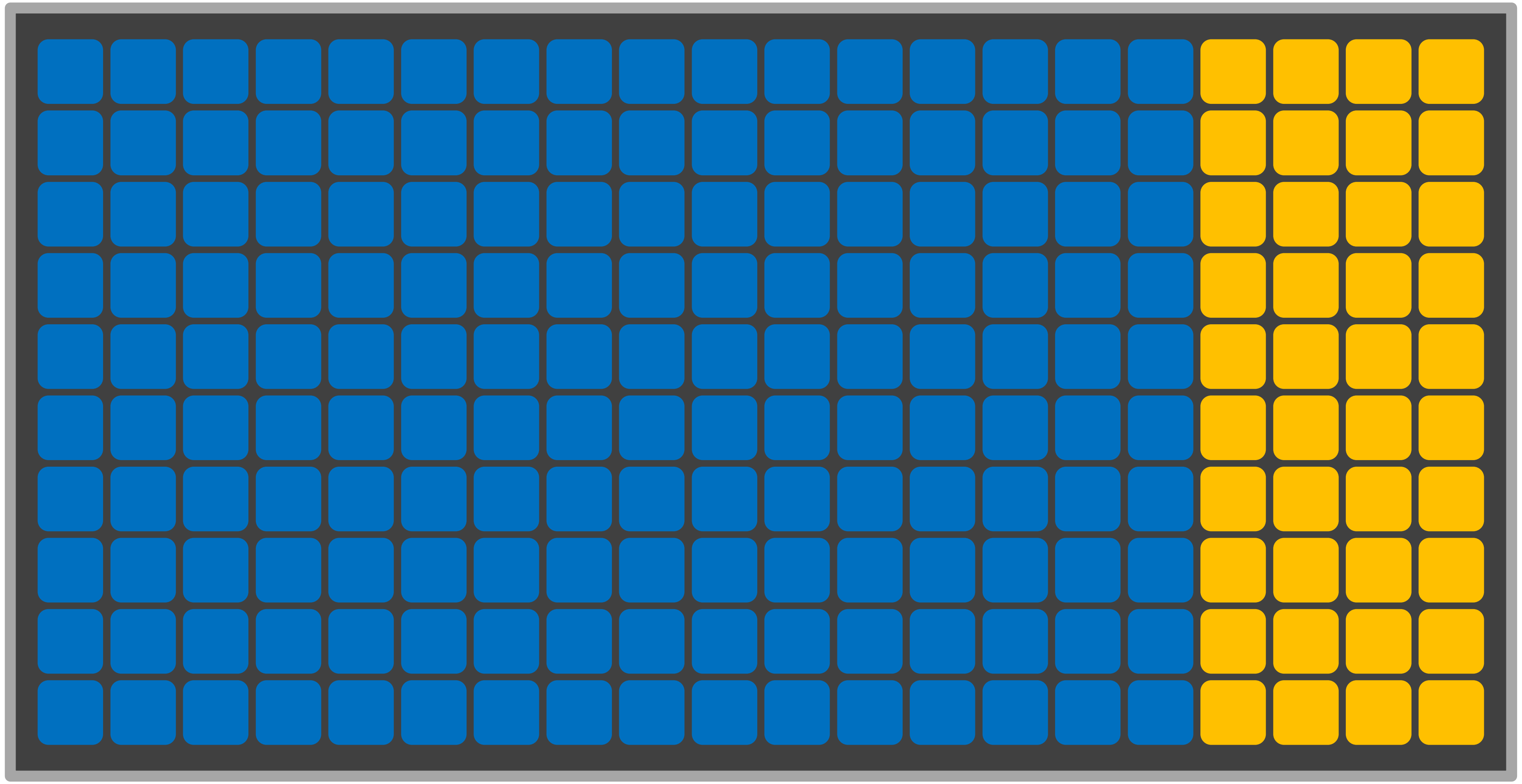
Shared Memory at the VTU-O



Each Square = 100 bytes | **Interleaver Memory** | **Unused Memory** | **Deinterleaver Memory**

- In this implementation, the following parameters were applied:
- RAM = 20 Kbytes
- Symmetric Service
- **Interleaver/deinterleaver memory = N*D; N=128 bytes per codeword; D=32 codewords**

Shared Memory



Each Square = 100 bytes | Interleaver Memory | Unused Memory | Deinterleaver Memory

- In this implementation, the following parameters were applied:
- RAM = 20 Kbytes
- Asymmetric Service
- **Interleaver memory = N*D; N= 255 bytes per codeword; D=64 codewords**
- **Deinterleaver memory = N*D; N=128 bytes per codeword; D=32 codewords**

Alleged Solutions

Figure 2

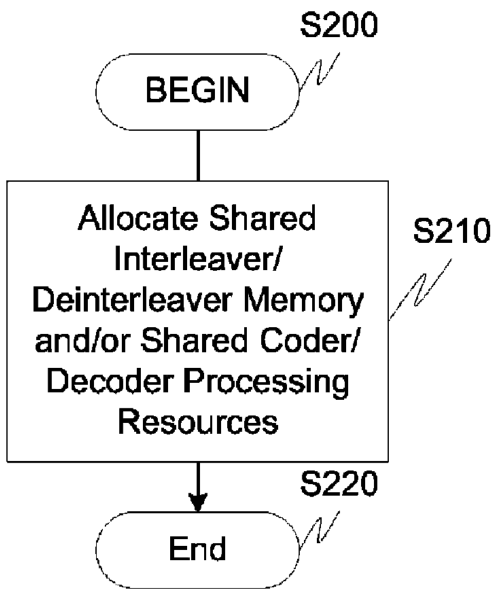


Figure 3

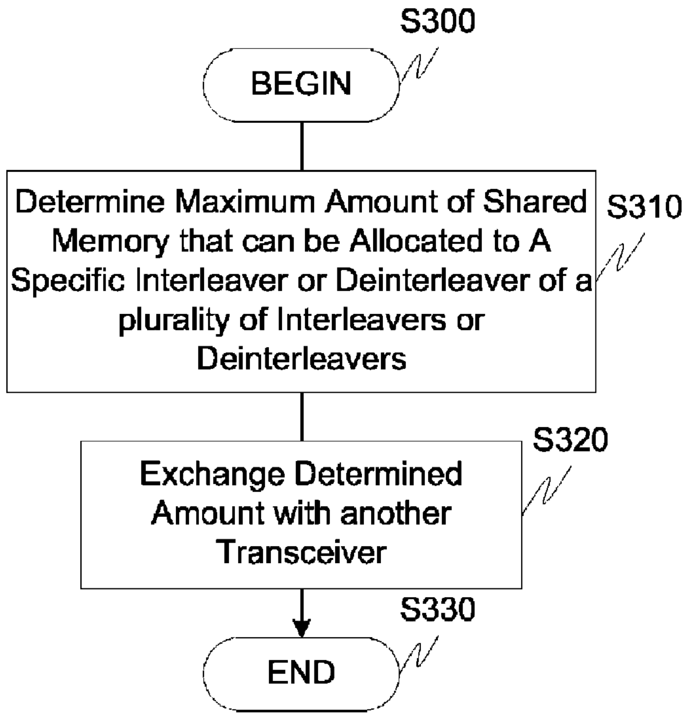
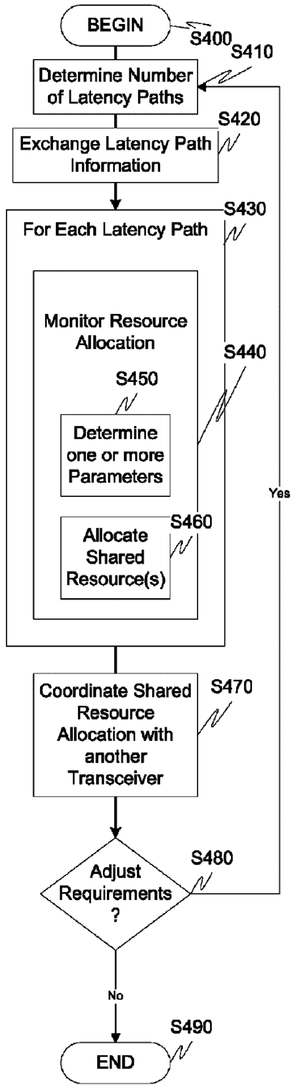
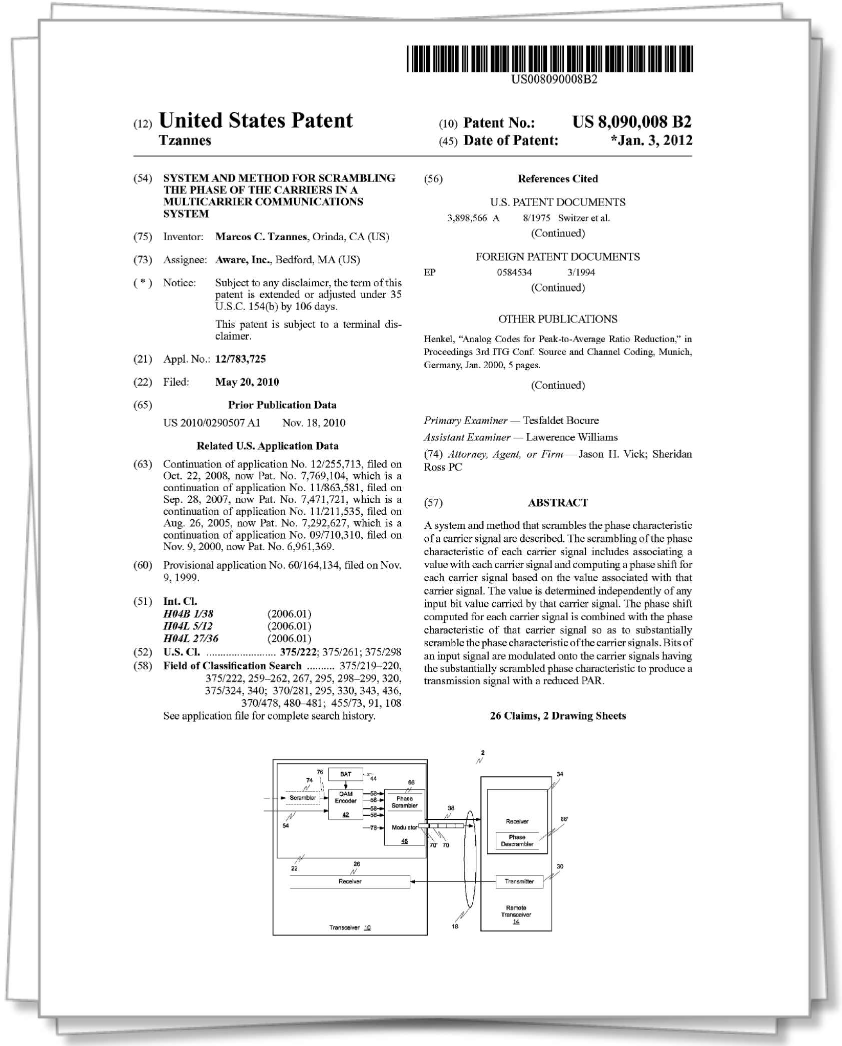


Figure 4



- Transmit message indicating memory allocation between interleaver/deinterleaver
- Transmit message indicating maximum amount of shared memory that can be allocated
- Updating the shared memory allocation based on changing conditions

Family 4 – Scrambling the Phase of the Carriers



US008090008B2

(12) United States Patent
Tzannes

(10) Patent No.: US 8,090,008 B2
(45) Date of Patent: *Jan. 3, 2012

(54) SYSTEM AND METHOD FOR SCRAMBLING THE PHASE OF THE CARRIERS IN A MULTICARRIER COMMUNICATIONS SYSTEM

(75) Inventor: **Marcos C. Tzannes**, Orinda, CA (US)

(73) Assignee: **Aware, Inc.**, Bedford, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 106 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/783,725**

(22) Filed: **May 20, 2010**

(65) **Prior Publication Data**

US 2010/0290507 A1 Nov. 18, 2010

Related U.S. Application Data

(63) Continuation of application No. 12/255,713, filed on Oct. 22, 2008, now Pat. No. 7,769,104, which is a continuation of application No. 11/863,581, filed on Sep. 28, 2007, now Pat. No. 7,471,721, which is a continuation of application No. 11/211,535, filed on Aug. 26, 2005, now Pat. No. 7,292,627, which is a continuation of application No. 09/710,310, filed on Nov. 9, 2000, now Pat. No. 6,961,369.

(60) Provisional application No. 60/164,134, filed on Nov. 9, 1999.

(51) **Int. Cl.**
H04B 1/38 (2006.01)
H04L 5/12 (2006.01)
H04L 27/36 (2006.01)

(52) **U.S. Cl.** **375/222**; 375/261; 375/298

(58) **Field of Classification Search** 375/219–220, 375/222, 259–262, 267, 295, 298–299, 320, 375/324, 340; 370/281, 295, 330, 343, 436, 370/478, 480–481; 455/73, 91, 108

See application file for complete search history.

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(Continued)

Primary Examiner — Tesfaldet Bocure
Assistant Examiner — Lawerence Williams
(74) *Attorney, Agent, or Firm* — Jason H. Vick; Sheridan Ross PC

(57) **ABSTRACT**

A system and method that scrambles the phase characteristic of a carrier signal are described. The scrambling of the phase characteristic of each carrier signal includes associating a value with each carrier signal and computing a phase shift for each carrier signal based on the value associated with that carrier signal. The value is determined independently of any input bit value carried by that carrier signal. The phase shift computed for each carrier signal is combined with the phase characteristic of that carrier signal so as to substantially scramble the phase characteristic of the carrier signals. Bits of an input signal are modulated onto the carrier signals having the substantially scrambled phase characteristic to produce a transmission signal with a reduced PAR.

26 Claims, 2 Drawing Sheets

Title: System and Method for Scrambling the Phase of the Carriers in a Multicarrier Communications System

Inventors: Marcos C. Tzannes

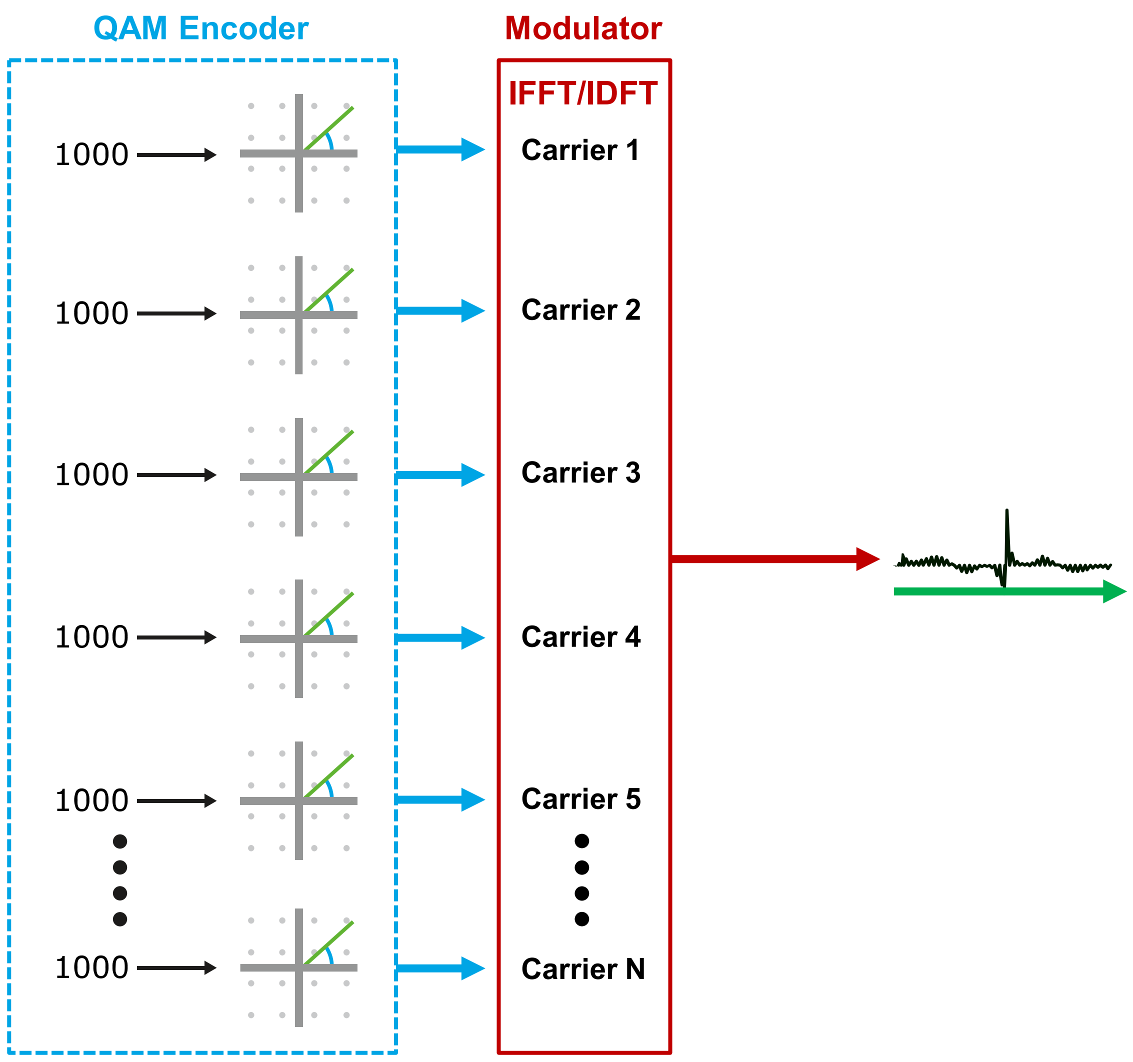
Earliest Alleged Priority: November 9, 1999

Expired

Asserted Claims: 14

Alleged Problem

If the phase of the modulated carriers is not random, then the PAR can increase greatly. Examples of cases where the phases of the modulated carrier signals are not random are when bit scramblers are not used, multiple carrier signals are used to modulate the same input data bits, and the constellation maps, which are mappings of input data bits to the phase of a carrier signal, used for modulation are not random enough (i.e., a zero value for a data bit corresponds to a 90 degree phase characteristic of the DMT carrier signal and a one value for a data bit corresponds to a –90 degree phase characteristic of the DMT carrier signal). An increased PAR can result in a system with high power consumption and/or with high probability of clipping the transmission signal. Thus, there remains a need for a system and method that can effectively scramble the phase of the modulated carrier signals in order to provide a low PAR for the transmission signal.



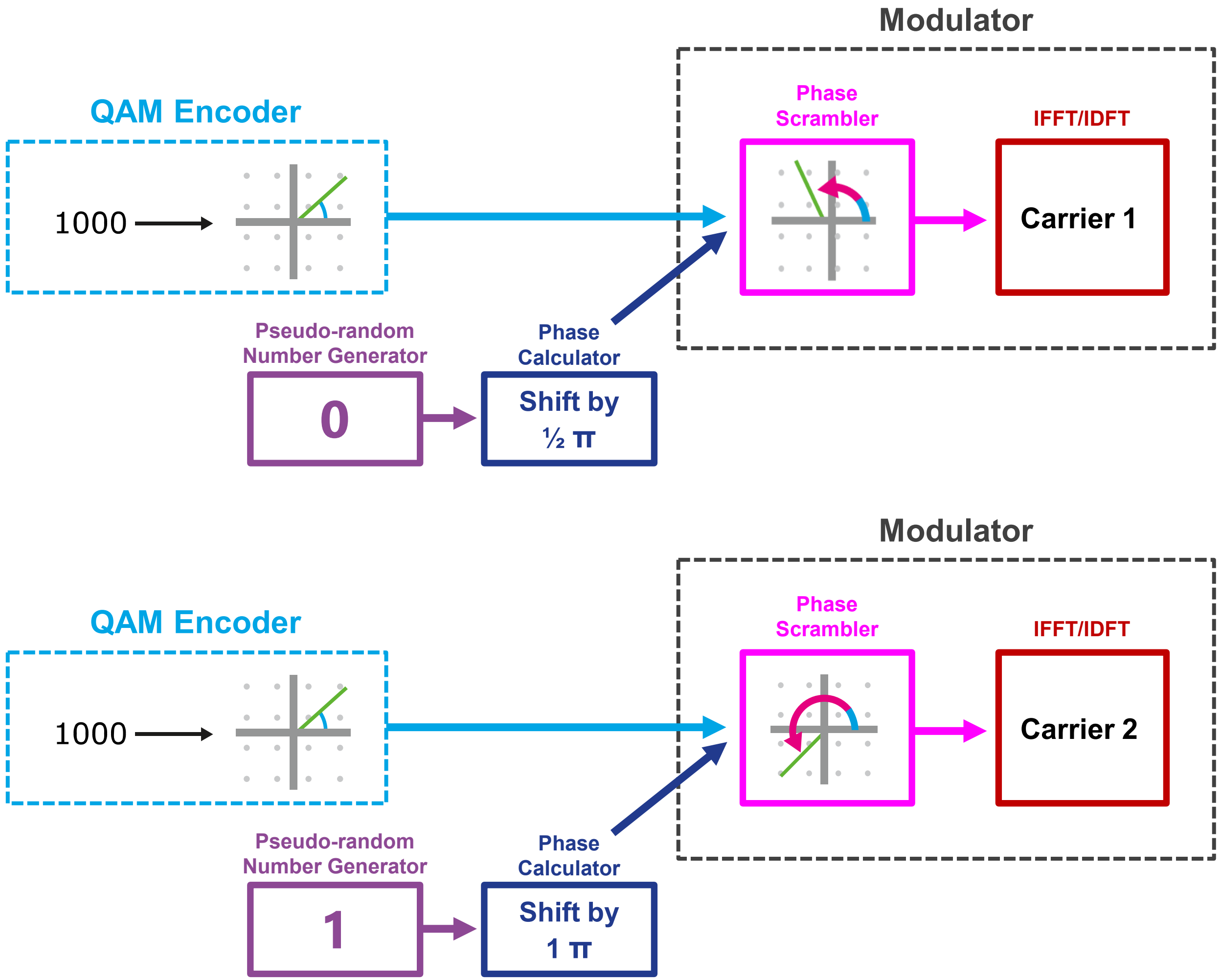
- The Family 4 Patent generally relates to phase scrambling of carrier signals.
- The Family 4 Patent explains that, when performing QAM or QPSK modulation, for example, issues can arise if the phases of the carrier signals are not sufficiently random.
- If the phases of the carrier signals are not sufficiently random, this can result in an increased peak to average power ratio (PAR). Increased PAR can be visualized as sharp peaks in the transmission signal. An increased PAR can result in a system with high power consumption and/or with high probability of clipping the transmission signal.

'008 Patent at 2:15-30

Alleged Solution

The present invention features a system and method that scrambles the phase characteristics of the modulated carrier signals in a transmission signal. In one aspect, a value is associated with each carrier signal. A phase shift is computed for each carrier signal based on the value associated with that carrier signal. The value is determined independently of any input bit value carried by that carrier signal. The phase shift computed for each carrier signal is combined with the phase characteristic of that carrier signal to substantially scramble the phase characteristics of the carrier signals.

In one embodiment, the input bit stream is modulated onto the carrier signals having the substantially scrambled phase characteristic to produce a transmission signal with a reduced peak-to-average power ratio (PAR). The value is derived from a predetermined parameter, such as a random number generator, a carrier number, a DMT symbol count, a superframe count, and a hyperframe count. In another embodiment, a predetermined transmission signal is transmitted when the amplitude of the transmission signal exceeds a certain level.



- The alleged solution of the Family 4 Patent is to scramble the phase of the carrier signals, which the Family 4 Patent describes as producing a transmission signal with a reduced PAR.
- To scramble the phase of the carrier signals, first "a value is associated with each carrier signal." The "value is determined independently of any input bit value carried by that carrier signal," such as by a pseudo-random number generator.
- Based on the value associated with that carrier signal, a phase shift is computed for each carrier signal. The phase shift is combined with the phase characteristic of that carrier signal to substantially scramble the phase characteristic of the carrier signal.

'008 Patent at 2:34-52

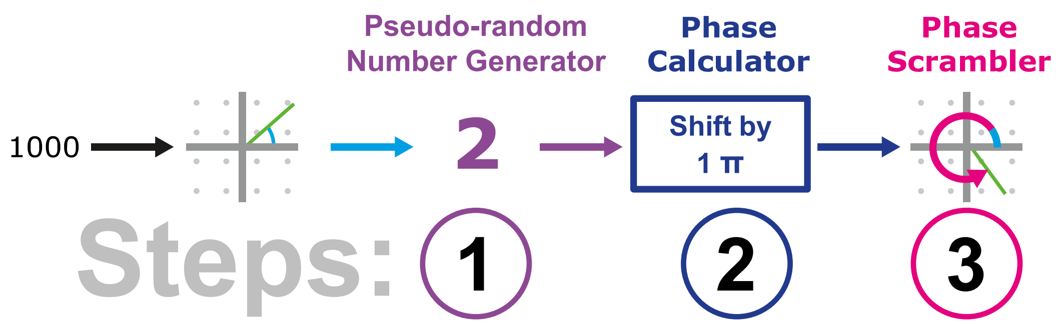
Asserted Claim

14. A multicarrier system including a first transceiver that uses a plurality of carrier signals for modulating a bit stream, wherein each carrier signal has a phase characteristic associated with the bit stream, the transceiver capable of:

associating each carrier signal with a value determined independently of any bit value of the bit stream carried by that respective carrier signal, the value associated with each carrier signal determined using a pseudo-random number generator;

computing a phase shift for each carrier signal based on the value associated with that carrier signal; and

combining the phase shift computed for each respective carrier signal with the phase characteristic of that carrier signal to substantially scramble the phase characteristics of the plurality of carrier signals, wherein multiple carrier signals corresponding to the scrambled carrier signals are used by the first transceiver to modulate the same bit value.

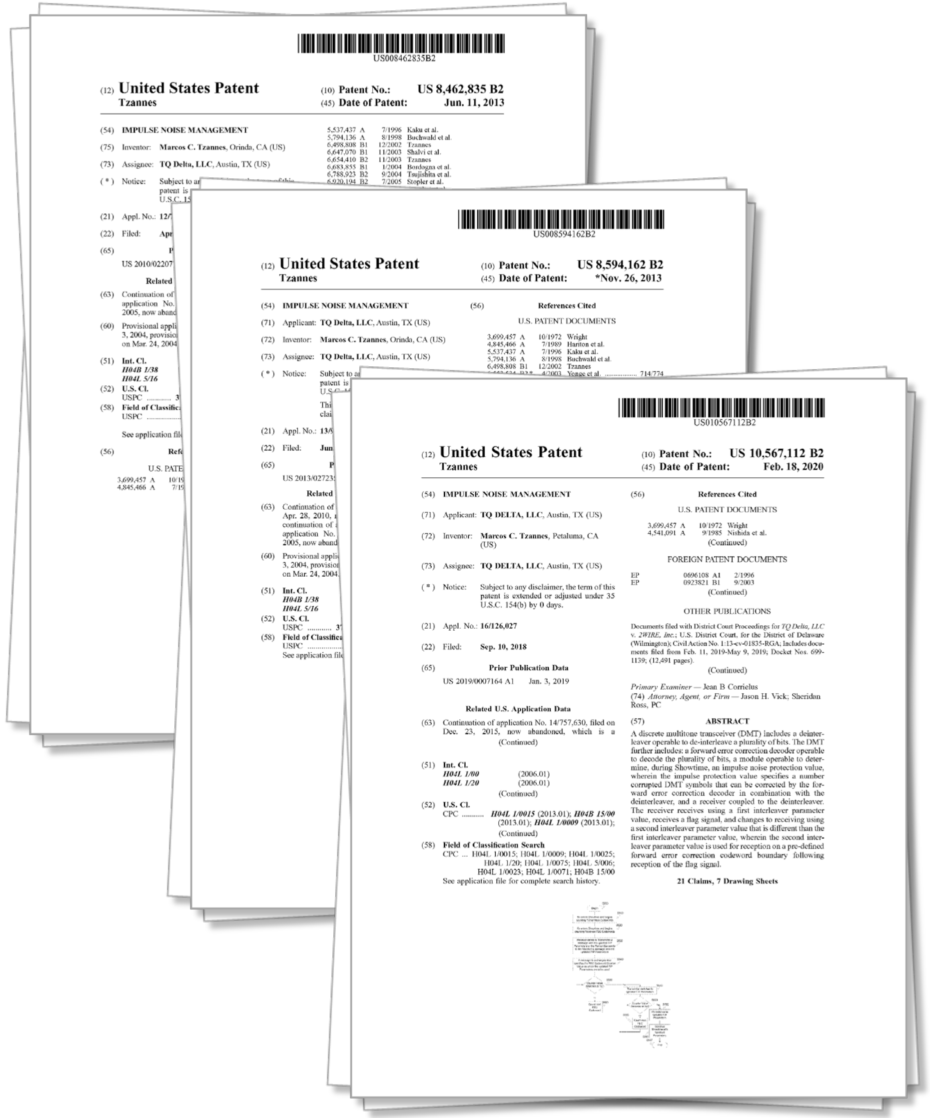


1. Associate each carrier signal with a value determined independently of any bit value of the bit stream, using a pseudo-random number generator

2. Compute a phase shift based on the value

3. Combine the phase shift computed with the phase characteristic of that carrier signal

Family 6 – Impulse Noise Management



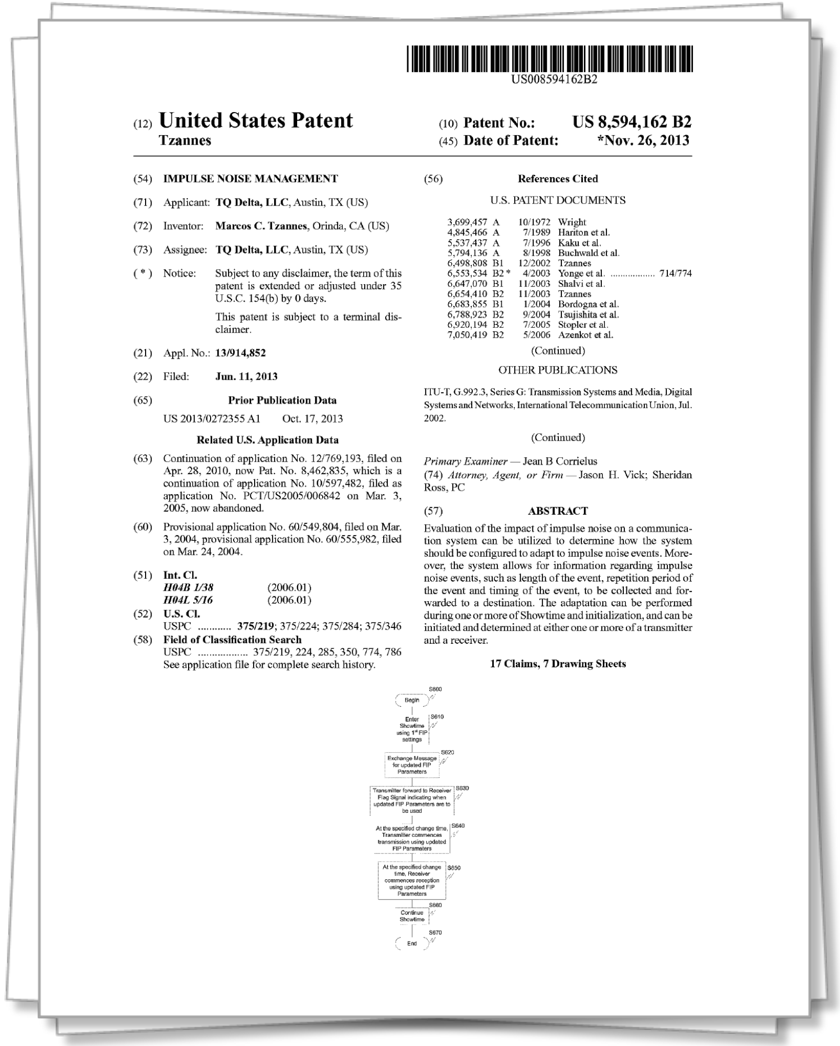
Title: Impulse Noise Management

Inventors: Marcos C. Tzannes

Earliest Alleged Priority: March 24, 2004

Asserted Claims: 835: 8, 10, **24,** and 26; **162: 8,** 9, 11; **112: 8,** 10, 11, 12, and 14

Alleged Problem



US008594162B2

(12) United States Patent
Tzannes

(10) Patent No.: US 8,594,162 B2
(45) Date of Patent: *Nov. 26, 2013

(54) IMPULSE NOISE MANAGEMENT

(71) Applicant: **TQ Delta, LLC**, Austin, TX (US)

(72) Inventor: **Marcos C. Tzannes**, Orinda, CA (US)

(73) Assignee: **TQ Delta, LLC**, Austin, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/914,852**

(22) Filed: **Jun. 11, 2013**

(65) **Prior Publication Data**

US 2013/0272355 A1 Oct. 17, 2013

Related U.S. Application Data

(63) Continuation of application No. 12/769,193, filed on Apr. 28, 2010, now Pat. No. 8,462,835, which is a continuation of application No. 10/597,482, filed as application No. PCT/US2005/006842 on Mar. 3, 2005, now abandoned.

(60) Provisional application No. 60/549,804, filed on Mar. 3, 2004, provisional application No. 60/555,982, filed on Mar. 24, 2004.

(51) **Int. Cl.**
H04B 1/38 (2006.01)
H04L 5/16 (2006.01)

(52) **U.S. Cl.**
USPC **375/219**; 375/224; 375/284; 375/346

(58) **Field of Classification Search**
USPC 375/219, 224, 285, 350, 774, 786
See application file for complete search history.

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Primary Examiner — Jean B Corrielus
(74) *Attorney, Agent, or Firm* — Jason H. Vick; Sheridan Ross, PC

(57) **ABSTRACT**

Evaluation of the impact of impulse noise on a communication system can be utilized to determine how the system should be configured to adapt to impulse noise events. Moreover, the system allows for information regarding impulse noise events, such as length of the event, repetition period of the event and timing of the event, to be collected and forwarded to a destination. The adaptation can be performed during one or more of Showtime and initialization, and can be initiated and determined at either one or more of a transmitter and a receiver.

17 Claims, 7 Drawing Sheets

2. Description of Related Art

Communications systems often operate in environments that produce impulse noise. Impulse noise is a short-term burst of noise that is higher than the normal noise that typically exists in a communication channel. For example, DSL systems operate on telephone lines and experience impulse noise from many external sources including telephones, AM radio, HAM radio, other DSL services on the same line or in the same bundle, other equipment in the home, etc. It is standard practice for communications systems to use interleaving in combination with Forward Error Correction (FEC) to correct the errors caused by impulse noise. Standard initialization procedures in ADSL and VDSL systems are designed to optimize performance (data rate/reach) in the presence "stationary" crosstalk or noise. Impulse noise protection is handled with interleaving and FEC, but the current xDSL procedure at least does not provide specific states to enable training for the selection of the appropriate interleaving and FEC parameters.

....

noise protection. The current technique includes the steps of an operator, or service provider, configuring the ADSL connection with a specific noise protection value, the ADSL connection is initialized and the transceivers enter into steady state data transmission (i.e., Showtime), and if the connection is stable, i.e., error-free, then the service is acceptable and the process ends. If there are bit errors, then the process is repeated with the operator, or service provider, configuring the ADSL connection with another specific INP value.

Prior Art

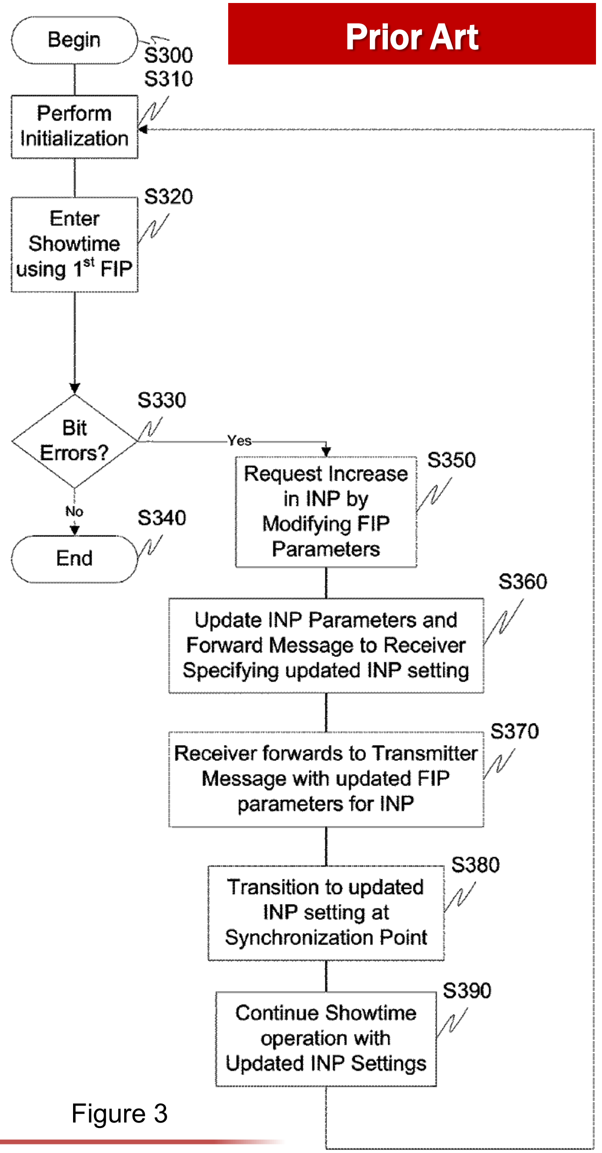
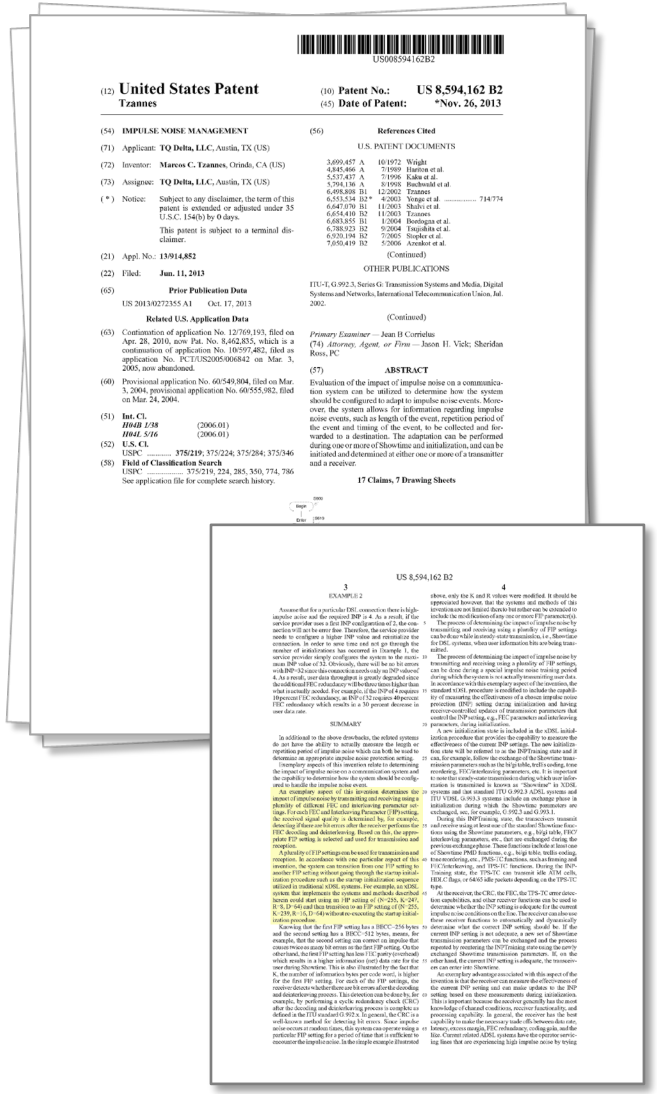


Figure 3

- The Family 6 Patents describe the use of interleaving and FEC encoding to correct errors caused by impulse noise.
- However, at the time of the Family 6 Patents, to update the interleaving and FEC encoding parameters, it was necessary to stop steady-state data transmission and re-configure the connection with another specific set of values.

Alleged Solution



An exemplary aspect of this invention determines the impact of impulse noise by transmitting and receiving using a plurality of different FEC and interleaving parameter settings. For each FEC and Interleaving Parameter (FIP) setting, the received signal quality is determined by, for example, detecting if there are bit errors after the receiver performs the FEC decoding and deinterleaving. Based on this, the appropriate FIP setting is selected and used for transmission and reception.

A plurality of FIP settings can be used for transmission and reception. In accordance with one particular aspect of this invention, the system can transition from one FIP setting to another FIP setting without going through the startup initialization procedure such as the startup initialization sequence utilized in traditional xDSL systems. For example, an xDSL system that implements the systems and methods described herein could start using an FIP setting of (N=255, K=247, R=8, D=64) and then transition to an FIP setting of (N=255, K=239, R=16, D=64) without re-executing the startup initialization procedure.

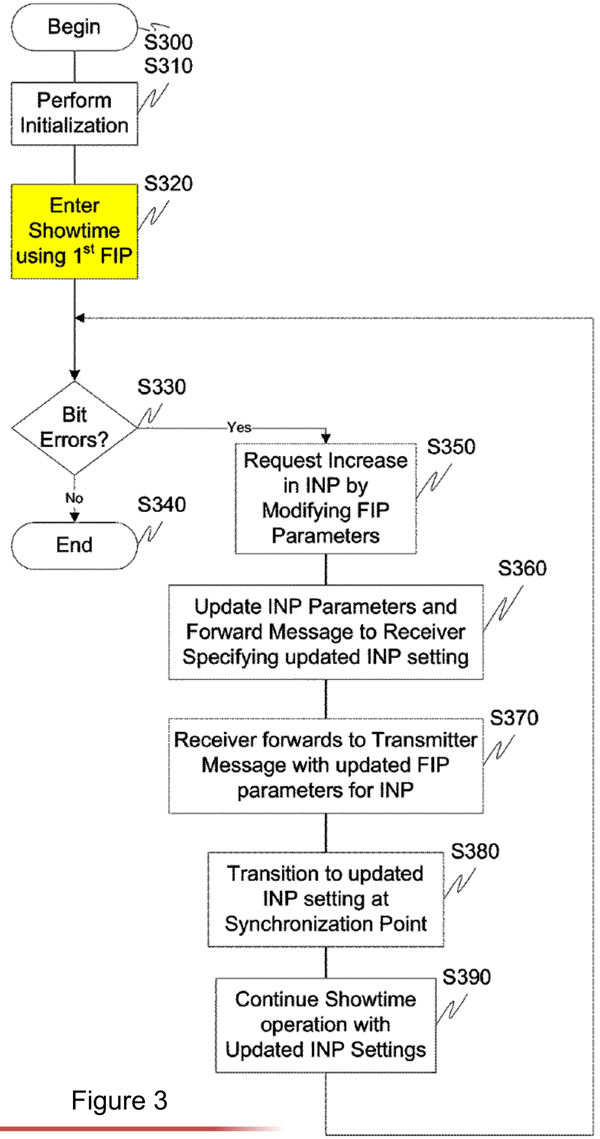
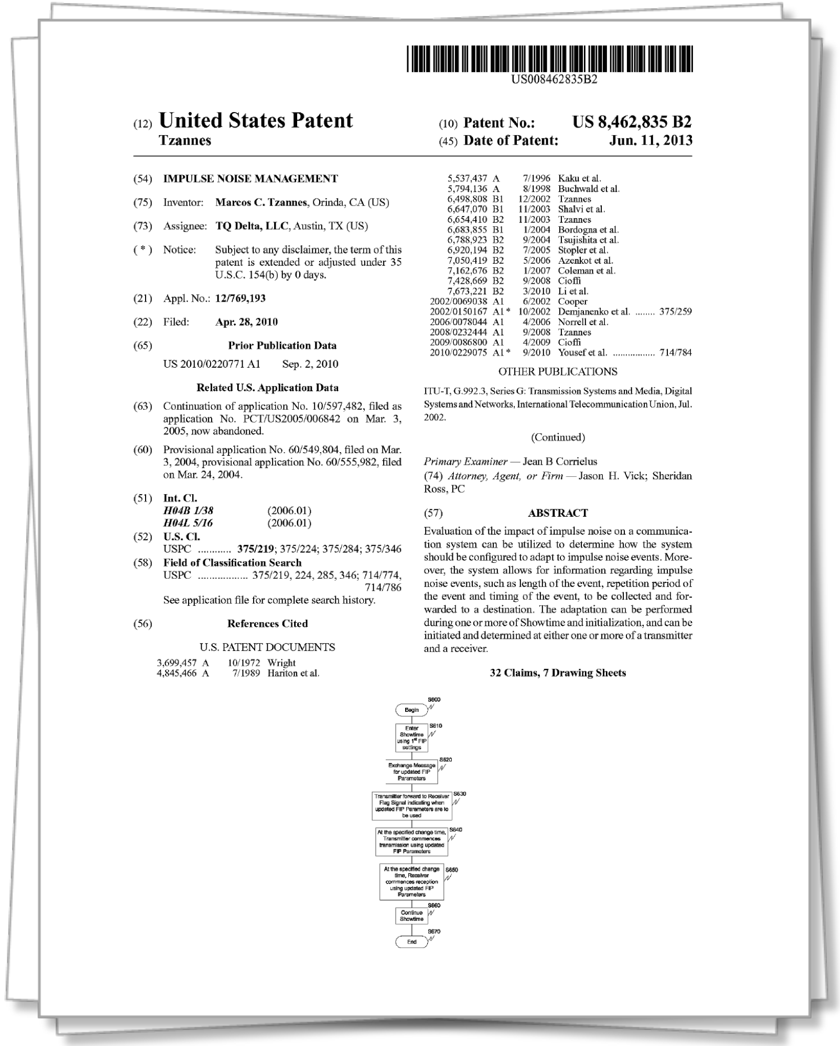


Figure 3

- The Family 6 Patents provide for apparatuses and methods such that the transceivers can transition from one set of parameters to another set of parameters without being required to again proceed through the startup initialization procedure.

'162 Patent at 3:30-49, Fig. 3

FIP Settings



US008462835B2

(12) **United States Patent**
Tzannes

(10) **Patent No.:** **US 8,462,835 B2**
(45) **Date of Patent:** **Jun. 11, 2013**

(54) IMPULSE NOISE MANAGEMENT

(75) Inventor: Marcos C. Tzannes, Orinda, CA (US)

(73) Assignee: TQ Delta, LLC, Austin, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: 12/769,193

(22) Filed: Apr. 28, 2010

(65) Prior Publication Data
US 2010/0220771 A1 Sep. 2, 2010

Related U.S. Application Data

(63) Continuation of application No. 10/597,482, filed as application No. PCT/US2005/006842 on Mar. 3, 2005, now abandoned.

(60) Provisional application No. 60/549,804, filed on Mar. 3, 2004, provisional application No. 60/555,982, filed on Mar. 24, 2004.

(51) Int. Cl.
H04B 1/38 (2006.01)
H04L 5/16 (2006.01)

(52) U.S. Cl.
USPC 375/219; 375/224; 375/284; 375/346

(58) Field of Classification Search
USPC 375/219, 224, 285, 346; 714/774, 714/786
See application file for complete search history.

(56) References Cited

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ITU-T, G.992.3, Series G: Transmission Systems and Media, Digital Systems and Networks, International Telecommunication Union, Jul. 2002.

(Continued)

Primary Examiner — Jean B Corrielus
(74) Attorney, Agent, or Firm — Jason H. Vick; Sheridan Ross, PC

(57) ABSTRACT

Evaluation of the impact of impulse noise on a communication system can be utilized to determine how the system should be configured to adapt to impulse noise events. Moreover, the system allows for information regarding impulse noise events, such as length of the event, repetition period of the event and timing of the event, to be collected and forwarded to a destination. The adaptation can be performed during one or more of Showtime and initialization, and can be initiated and determined at either one or more of a transmitter and a receiver.

32 Claims, 7 Drawing Sheets

A plurality of FIP settings can be used for transmission and reception. In accordance with one particular aspect of this invention, the system can transition from one FIP setting to another FIP setting without going through the startup initialization procedure such as the startup initialization sequence utilized in traditional xDSL systems. For example, an xDSL system that implements the systems and methods described herein could start using an FIP setting of (N=255, K=247, R=8, D=64) and then transition to an FIP setting of (N=255, K=239, R=16, D=64) without re-executing the startup initialization procedure.

....

order to handle high levels of impulse noise. Impulse noise protection is defined in the ADSL2 Standard G.992.3, which is incorporated herein by reference in its entirety, as the number of impulse noise corrupted DMT symbols that can be corrected by the FEC and interleaving configuration. Specifically, G.992.3 defines the following variables:

$$INP=1/2*(S*D)*R/N$$

$$S=8*N/L$$

$$\text{Latency (or delay)}=S*D/4$$

$$\text{Line Rate (in kbps)}=L*4$$

where N is the codeword size in bytes, R is the number of parity (or redundancy) bytes in a codeword, D is the interleaver depth in number of codewords, and L is the number of bits in a DMT symbol.

If K is the number of information bytes in a codeword then:

$$N=K+R$$

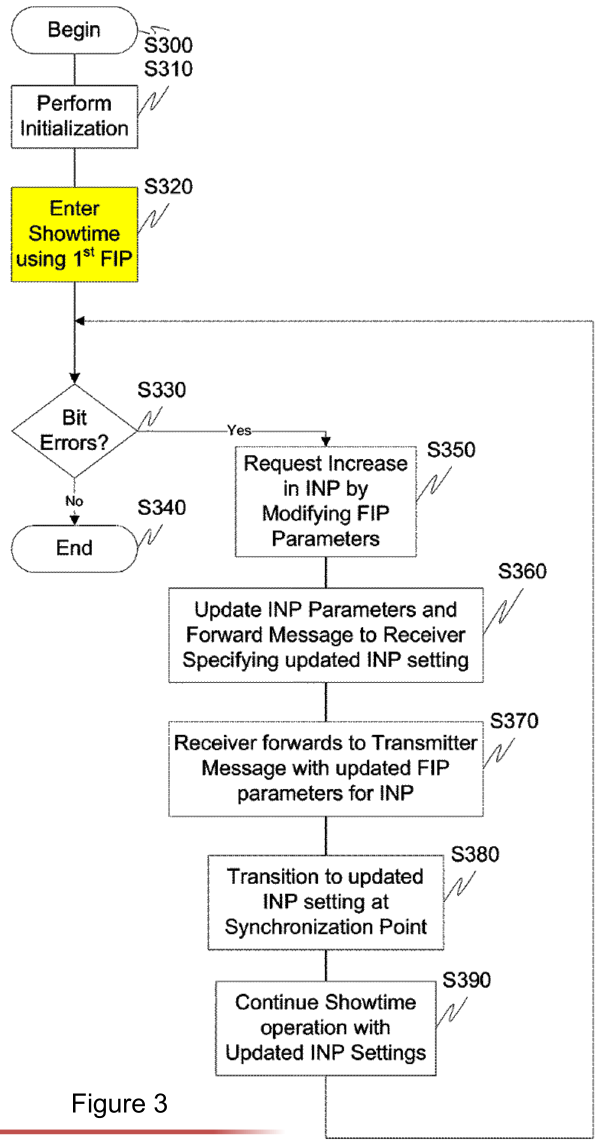
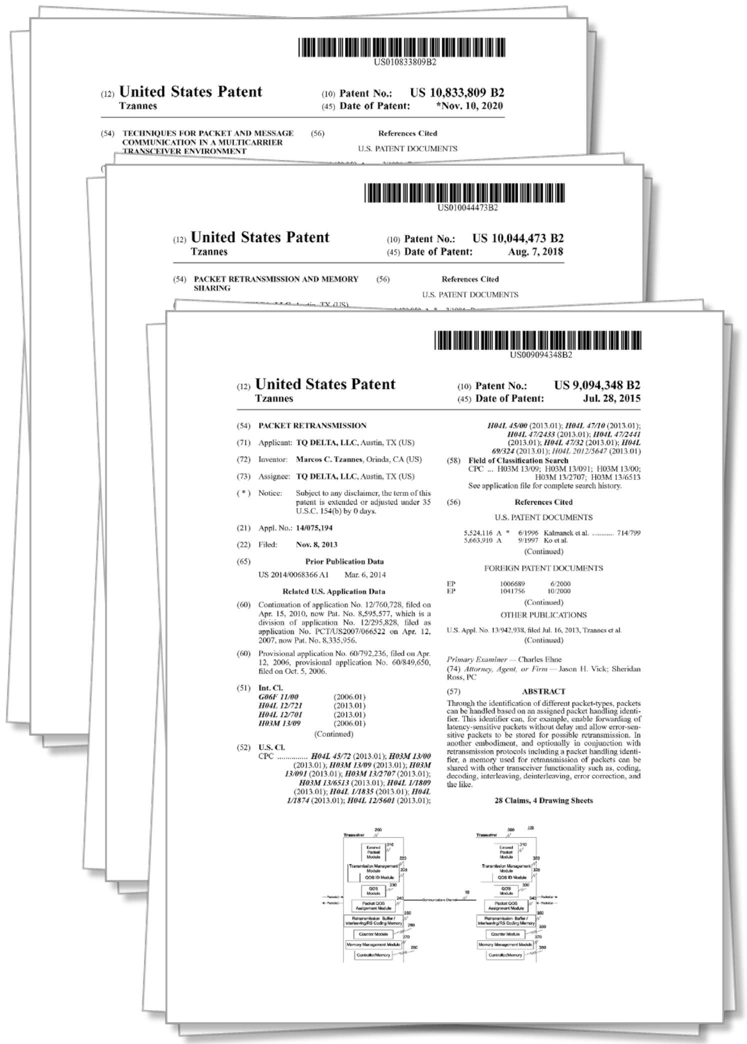
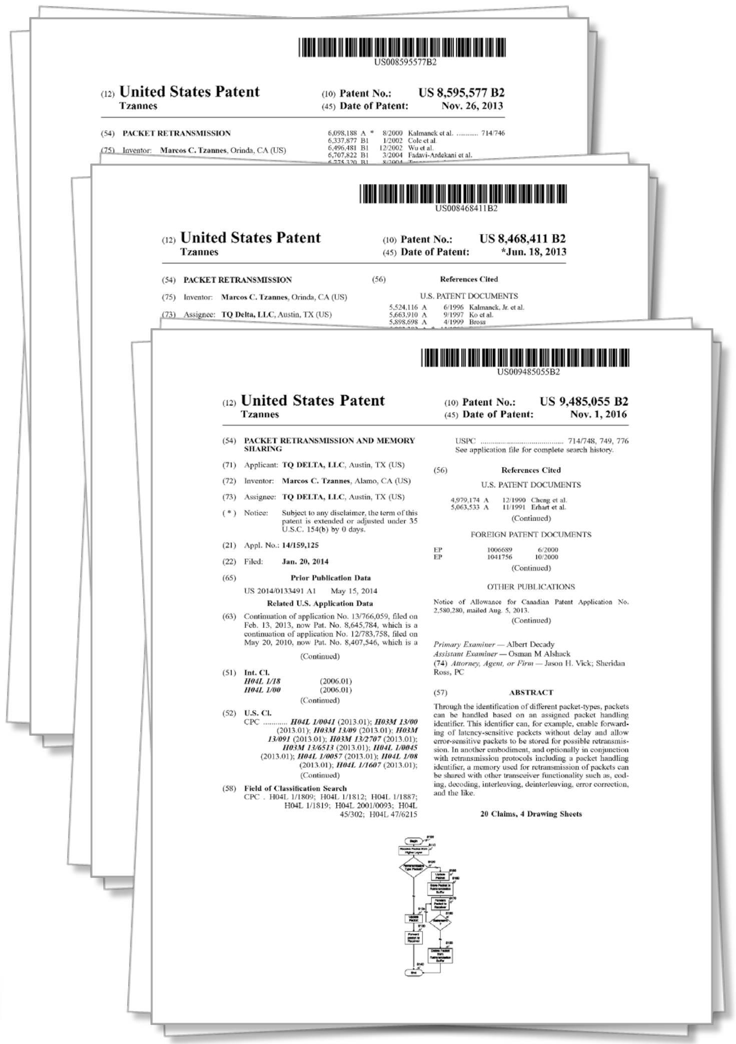


Figure 3

- The Family 6 Patents describe the FEC and interleaving parameters as "FIP settings," which the Patents define as the codeword size in bytes, the number of information bytes in a codeword, the number of parity or redundancy bytes in a codeword, and the interleaver depth in number of codewords.

Family 9 – Packet Retransmission





Title: Packet Retransmission (’577, ’348, ’411); Packet Retransmission and Memory Sharing (’4473, ’055); Techniques for Packet and Memory Communication in a Multicarrier Transceiver Environment (’809)

Inventor: Marcos C. Tzannes

Earliest Alleged Priority: Apr. 12, 2006

’577 Asserted Claims: 16, 18, **30**, 32, **37**-39, 44, **53**-55, 60

’348 Asserted Claims: 1-4, **9**-12

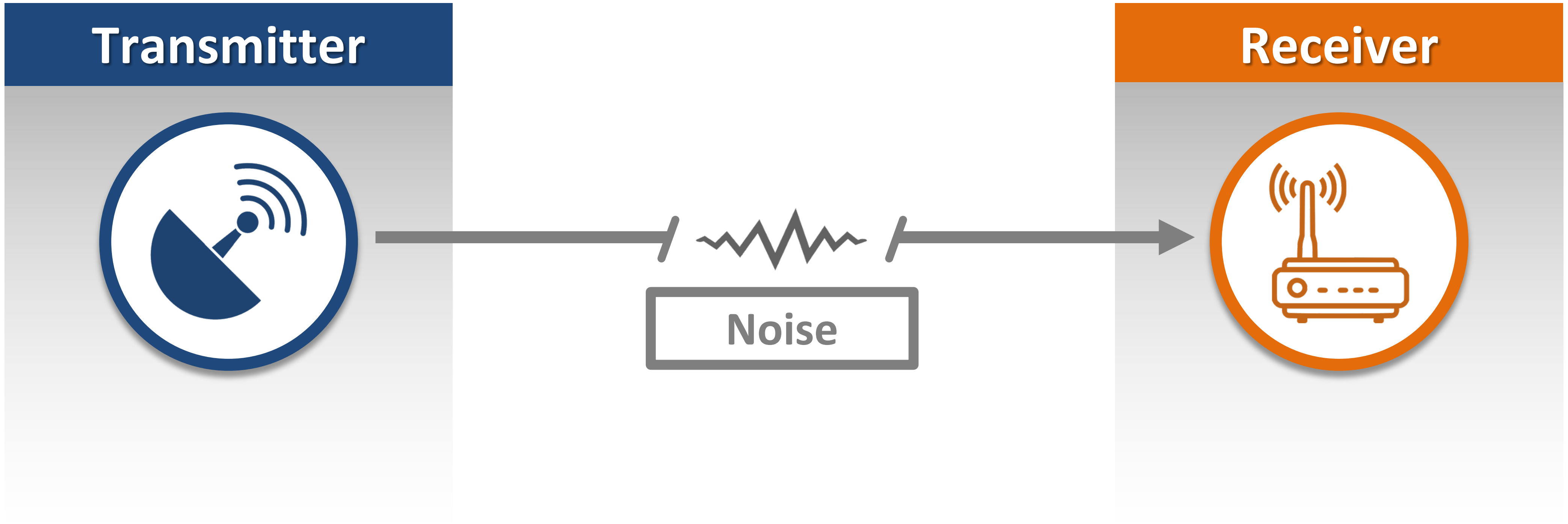
’4473 Asserted Claims: 1-4, 8

’809 Asserted Claims: 1-4, 6, **8**-13, **15**-18, 20, **22**-23, 25, 27

’411 Asserted Claims: 10, 11, 17, **18**, 25

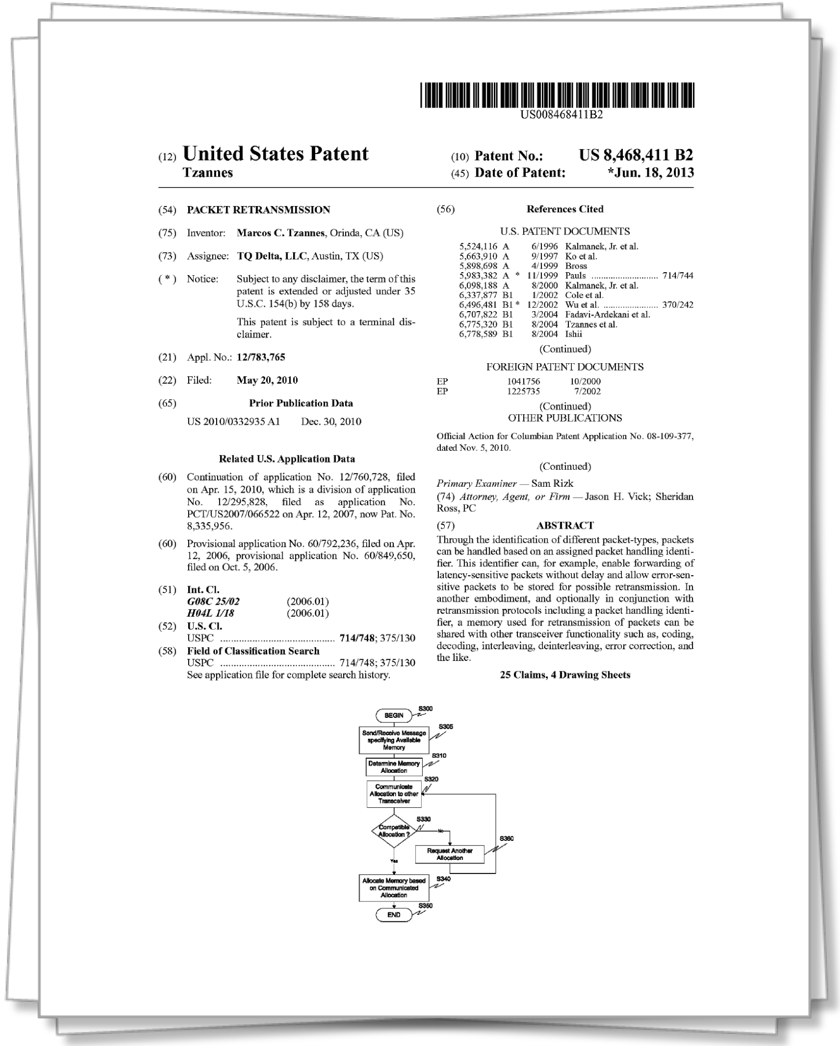
’055 Asserted Claims: 11, 17, 19

Alleged Problem in the Art



- Packets of data/information communicated over a communication channel may be corrupted by noise, including impulse noise.
- Therefore, not all transmitted packets will be correctly received by the receiving modem.

Alleged Solution



US008468411B2

(12) **United States Patent**
Tzannes

(10) **Patent No.:** **US 8,468,411 B2**
(45) **Date of Patent:** ***Jun. 18, 2013**

(54) **PACKET RETRANSMISSION**

(75) Inventor: **Marcos C. Tzannes**, Orinda, CA (US)

(73) Assignee: **TQ Delta, LLC**, Austin, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 158 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/783,765**

(22) Filed: **May 20, 2010**

(65) **Prior Publication Data**

US 2010/0332935 A1 Dec. 30, 2010

Related U.S. Application Data

(60) Continuation of application No. 12/760,728, filed on Apr. 15, 2010, which is a division of application No. 12/295,828, filed as application No. PCT/US2007/066522 on Apr. 12, 2007, now Pat. No. 8,335,956.

(60) Provisional application No. 60/792,236, filed on Apr. 12, 2006, provisional application No. 60/849,650, filed on Oct. 5, 2006.

(51) **Int. Cl.**
G08C 25/02 (2006.01)
H04L 1/18 (2006.01)

(52) **U.S. Cl.**
USPC **714/748**; 375/130

(58) **Field of Classification Search**
USPC 714/748; 375/130
See application file for complete search history.

(56) **References Cited**

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5,663,910	A	9/1997	Ko et al.	
5,898,698	A	4/1999	Bross	
5,983,382	A *	11/1999	Pauls	714/744
6,098,188	A	8/2000	Kalmanek, Jr. et al.	
6,337,877	B1	1/2002	Cole et al.	
6,496,481	B1 *	12/2002	Wu et al.	370/242
6,707,822	B1	3/2004	Fadavi-Ardekani et al.	
6,775,320	B1	8/2004	Tzannes et al.	
6,778,589	B1	8/2004	Ishii	

(Continued)

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EP	1225735	7/2002

(Continued)

OTHER PUBLICATIONS

Official Action for Columbian Patent Application No. 08-109-377, dated Nov. 5, 2010.

(Continued)

Primary Examiner — Sam Rizk
(74) *Attorney, Agent, or Firm* — Jason H. Vick; Sheridan Ross, PC

(57) **ABSTRACT**

Through the identification of different packet-types, packets can be handled based on an assigned packet handling identifier. This identifier can, for example, enable forwarding of latency-sensitive packets without delay and allow error-sensitive packets to be stored for possible retransmission. In another embodiment, and optionally in conjunction with retransmission protocols including a packet handling identifier, a memory used for retransmission of packets can be shared with other transceiver functionality such as, coding, decoding, interleaving, deinterleaving, error correction, and the like.

25 Claims, 4 Drawing Sheets

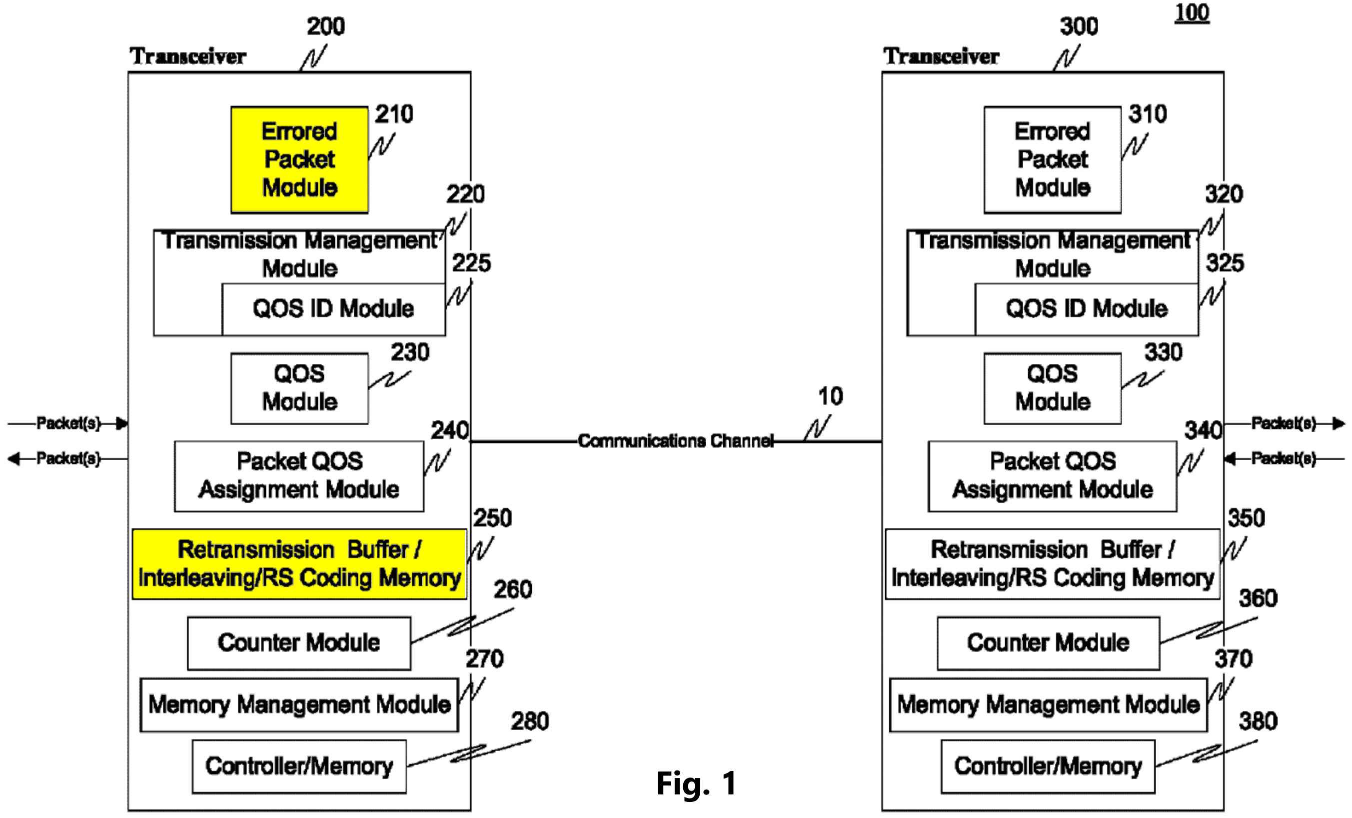
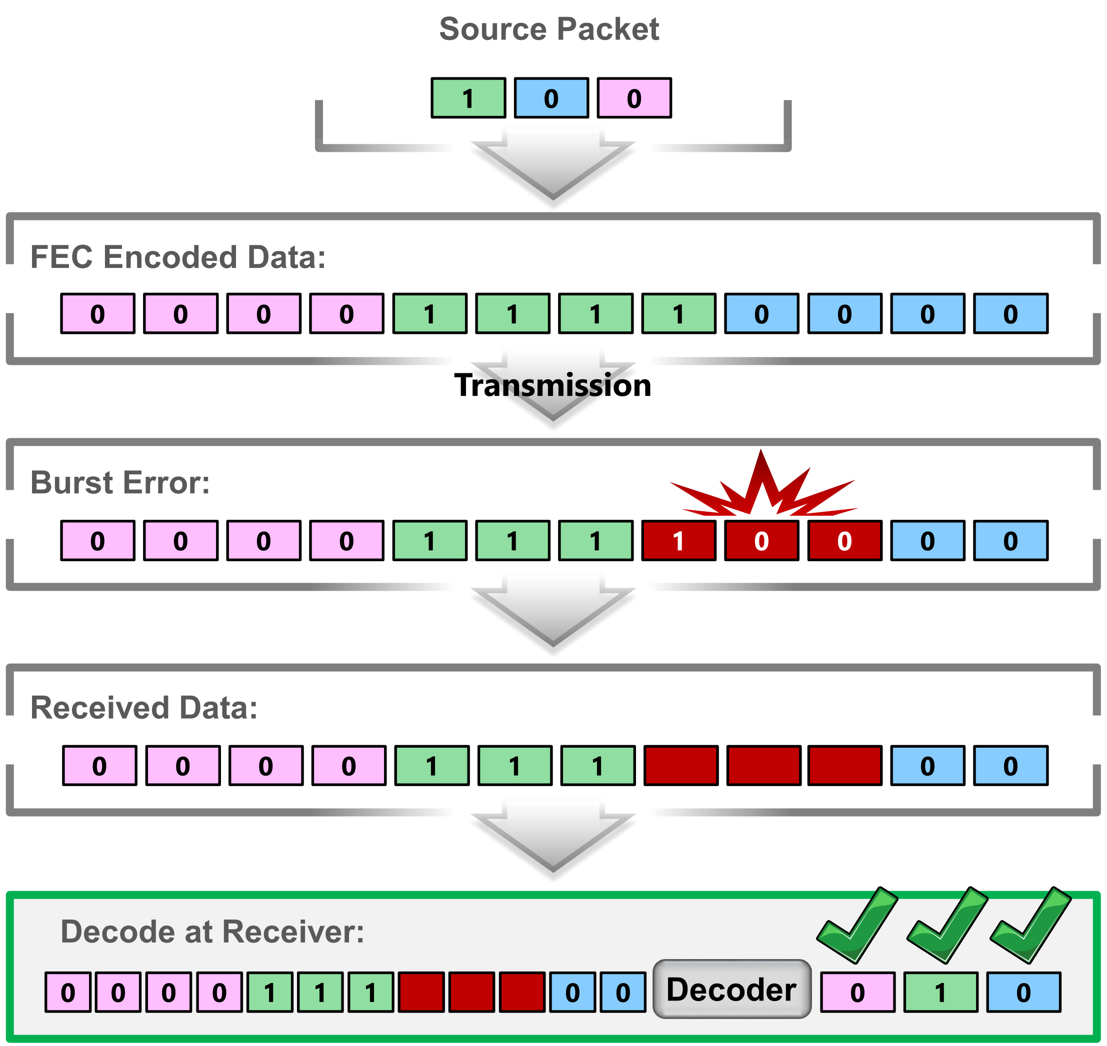


Fig. 1

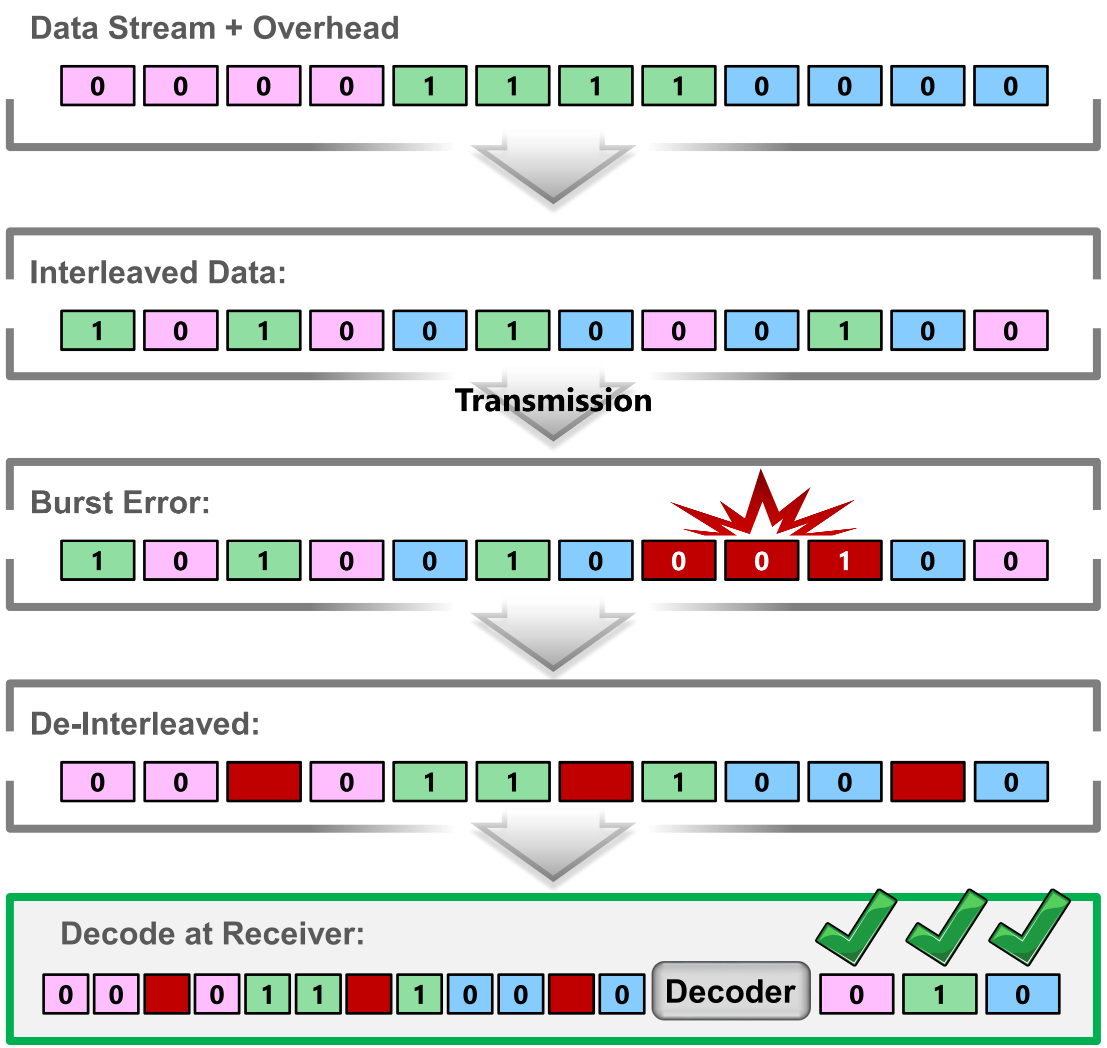
Combination of:

- (1) Forward Error Correction
- (2) Interleaving
- (3) Retransmission

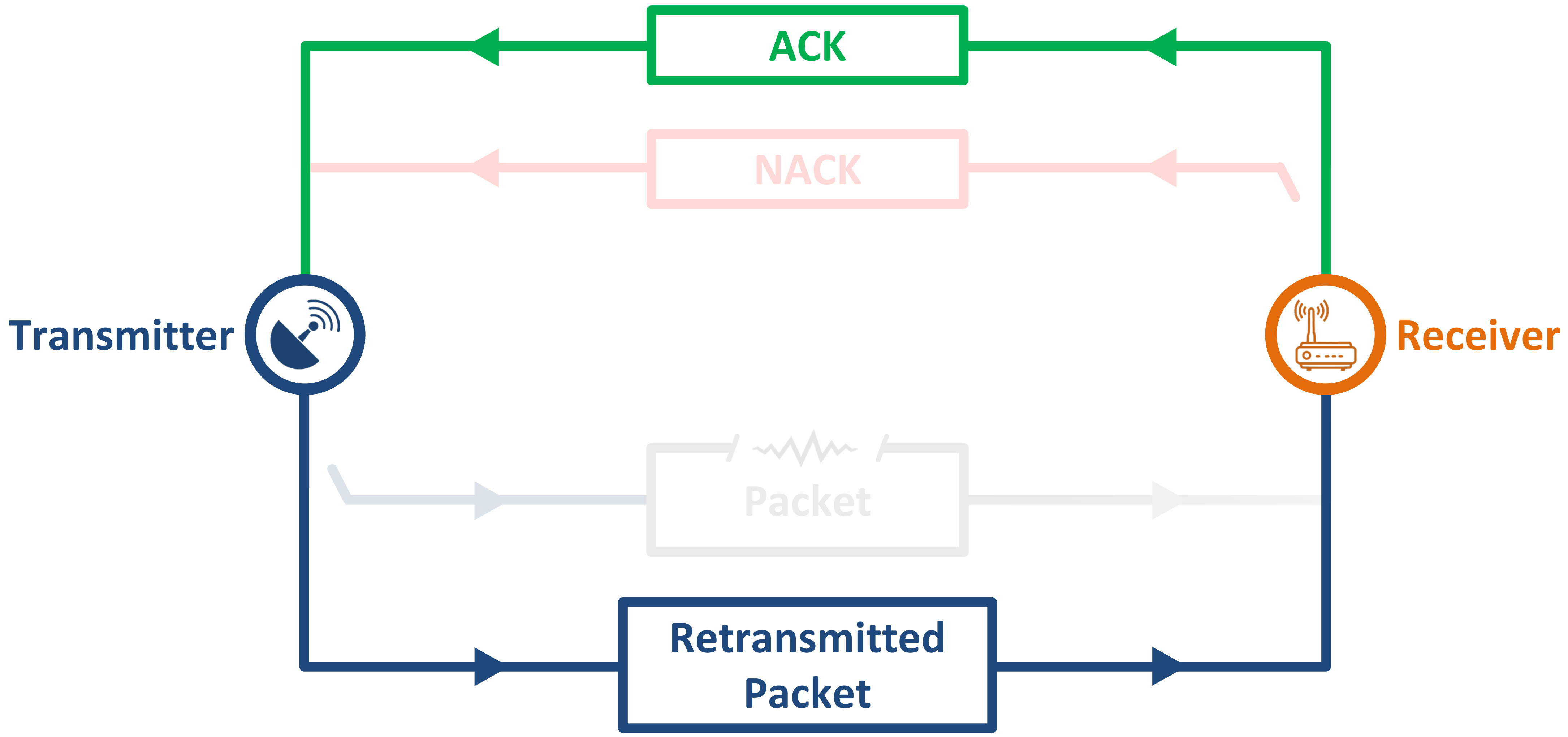
Alleged Solution – Part 1: Forward Error Correction (FEC)



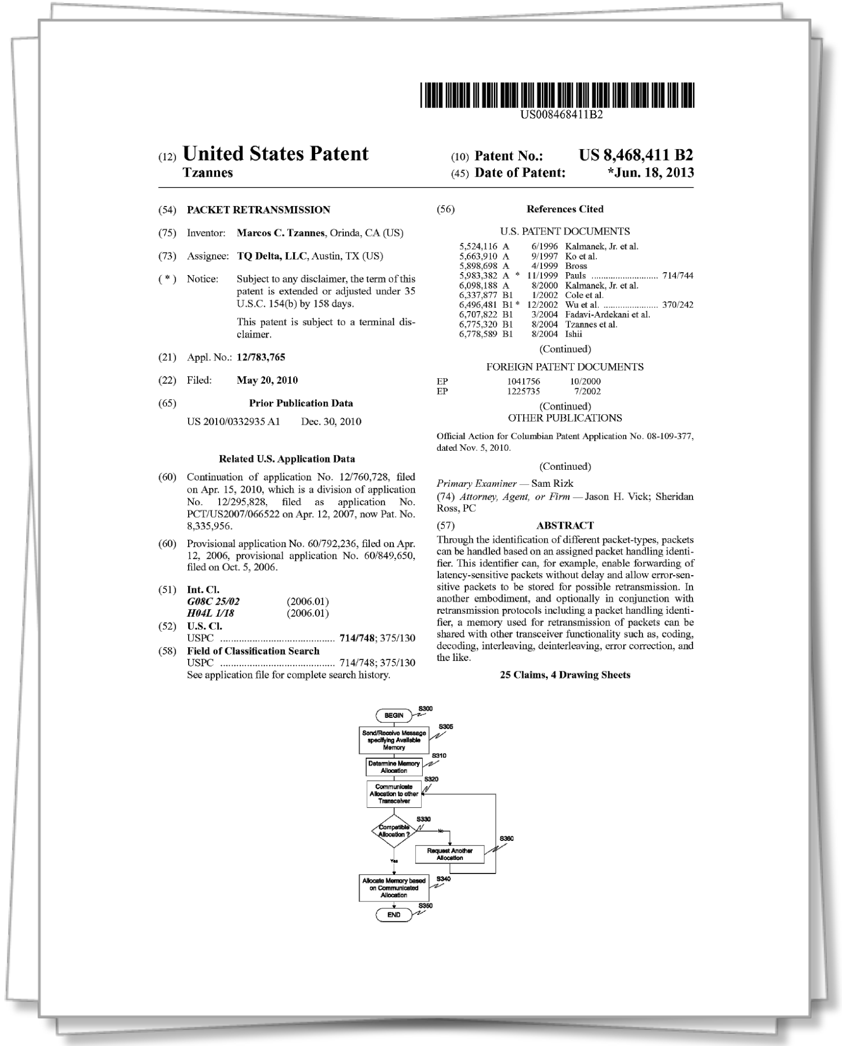
Alleged Solution – Part 2: Interleaving



Alleged Solution – Part 3: Retransmission



Additional Alleged Invention


US008468411B2

(12) **United States Patent**
Tzannes

(10) **Patent No.:** **US 8,468,411 B2**
(45) **Date of Patent:** ***Jun. 18, 2013**

(54) **PACKET RETRANSMISSION**

(75) Inventor: **Marcos C. Tzannes**, Orinda, CA (US)

(73) Assignee: **TQ Delta, LLC**, Austin, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 158 days.

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(21) Appl. No.: **12/783,765**

(22) Filed: **May 20, 2010**

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Related U.S. Application Data

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(51) **Int. Cl.**
G08C 25/02 (2006.01)
H04L 1/18 (2006.01)

(52) **U.S. Cl.**
USPC **714/748**; 375/130

(58) **Field of Classification Search**
USPC 714/748; 375/130
See application file for complete search history.

(56) **References Cited**

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5,983,382	A *	11/1999	Pauls	714/744
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6,496,481	B1 *	12/2002	Wu et al.	370/242
6,707,822	B1	3/2004	Fadavi-Ardekani et al.	
6,775,320	B1	8/2004	Tzannes et al.	
6,778,589	B1	8/2004	Ishii	

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(74) *Attorney, Agent, or Firm* — Jason H. Vick; Sheridan Ross, PC

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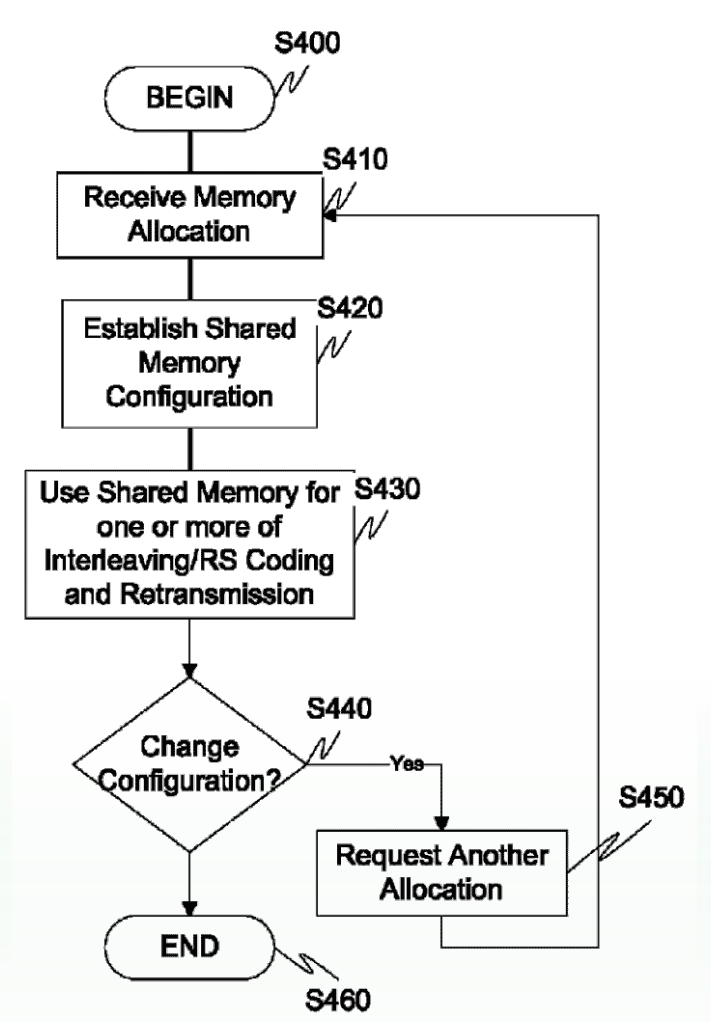
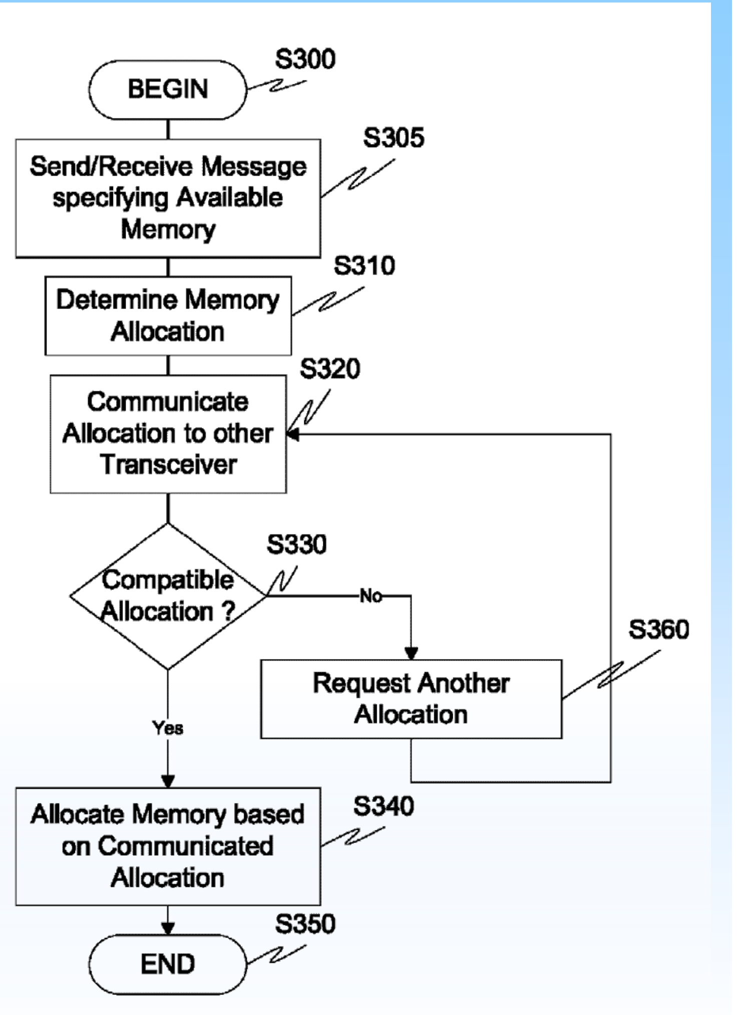
25 Claims, 4 Drawing Sheets

(Fig. 5)



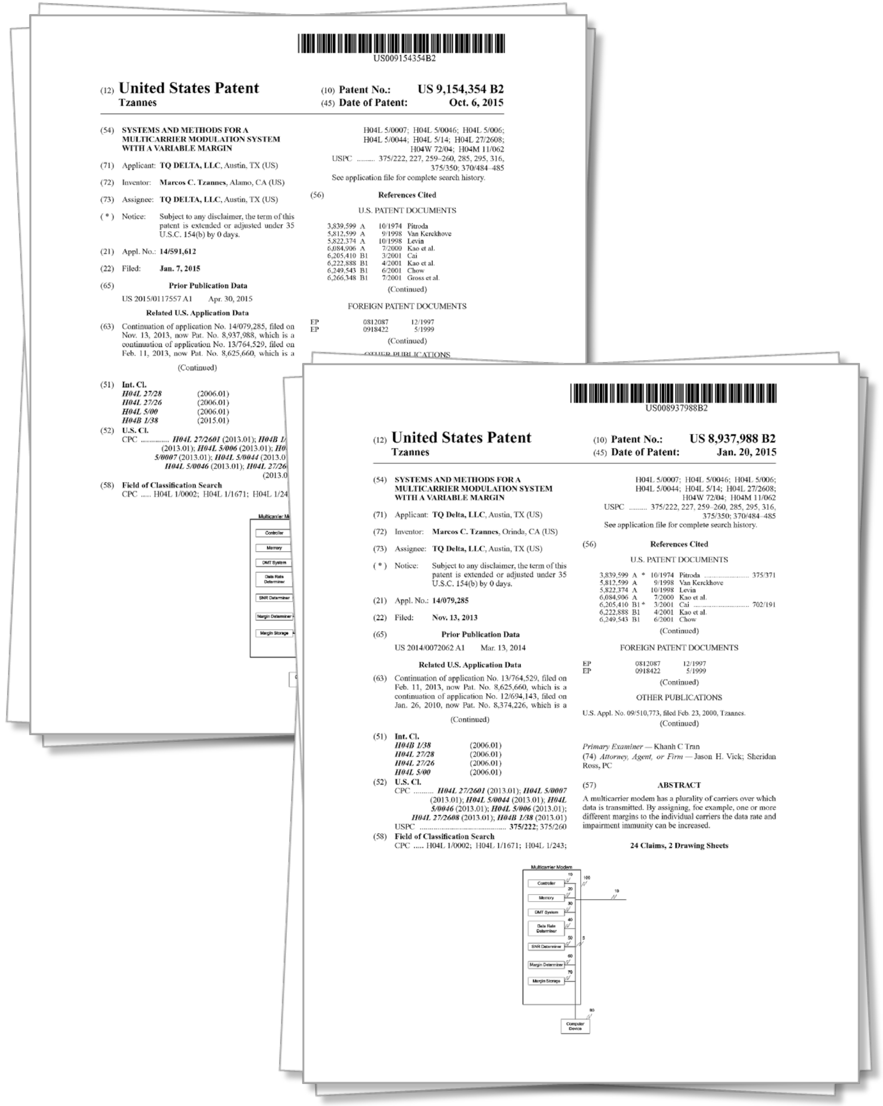
(Fig. 4).



- The Family 9 Patents are also directed to a system to sharing memory between an interleaver/deinterleaver device and a packet retransmission function, wherein the memory is allocated by a message.

'411 patent, Figs. 4 and 5

Family 10 – Variable Margin



Title: Systems and Methods for a Multicarrier Modulation System with a Variable Margin

Inventors: Marcos C. Tzannes

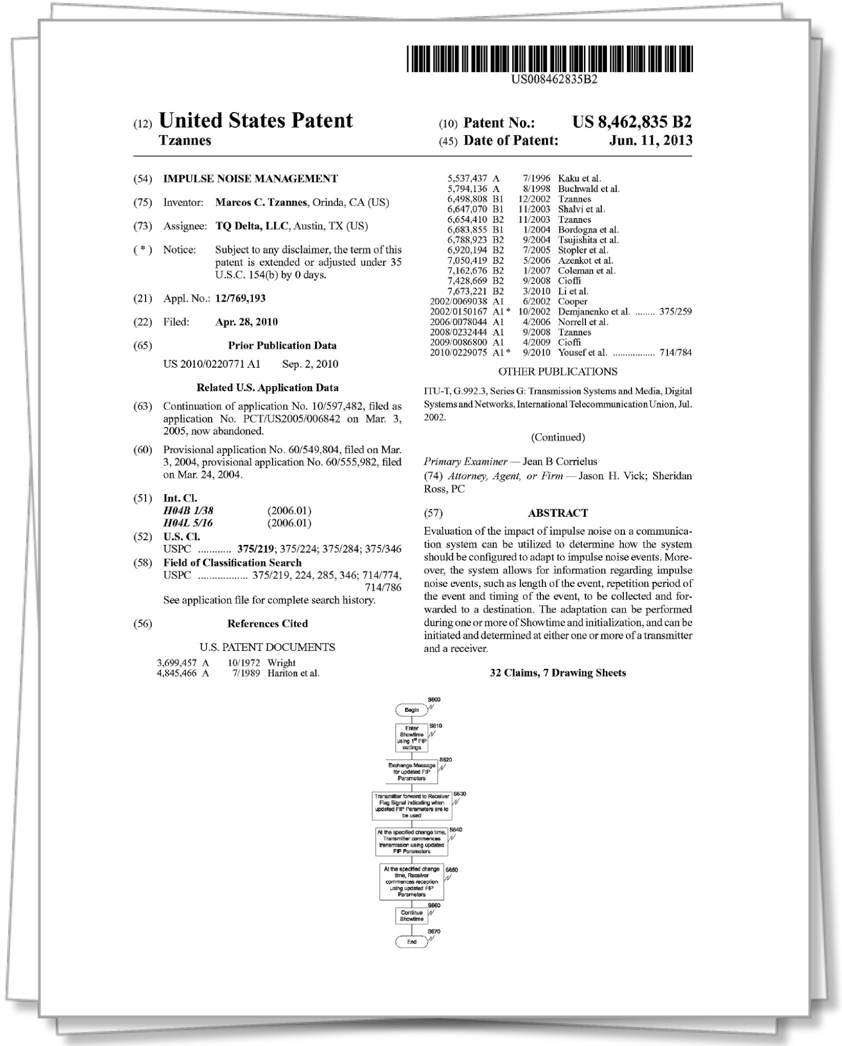
Earliest Alleged Priority: 04-18-2000

Expired

’354 Asserted Claims: 10, 11, 12

’988 Asserted Claims: 16, 22

Alleged Problem



US008462835B2

(12) **United States Patent**
Tzannes

(10) **Patent No.:** **US 8,462,835 B2**
(45) **Date of Patent:** **Jun. 11, 2013**

(54) **IMPULSE NOISE MANAGEMENT**

(75) Inventor: **Marcos C. Tzannes**, Orinda, CA (US)

(73) Assignee: **TQ Delta, LLC**, Austin, TX (US)

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(52) **U.S. Cl.**
USPC **375/219**; 375/224; 375/284; 375/346

(58) **Field of Classification Search**
USPC 375/219, 224, 285, 346; 714/774, 714/786
See application file for complete search history.

(56) **References Cited**

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2010/0229075	A1 *	9/2010	Yousef et al.	714/784

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ITU-T, G.992.3, Series G: Transmission Systems and Media, Digital Systems and Networks, International Telecommunication Union, Jul. 2002.

(Continued)

Primary Examiner — Jean B Corrielus
(74) *Attorney, Agent, or Firm* — Jason H. Vick; Sheridan Ross, PC

(57) **ABSTRACT**

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32 Claims, 7 Drawing Sheets

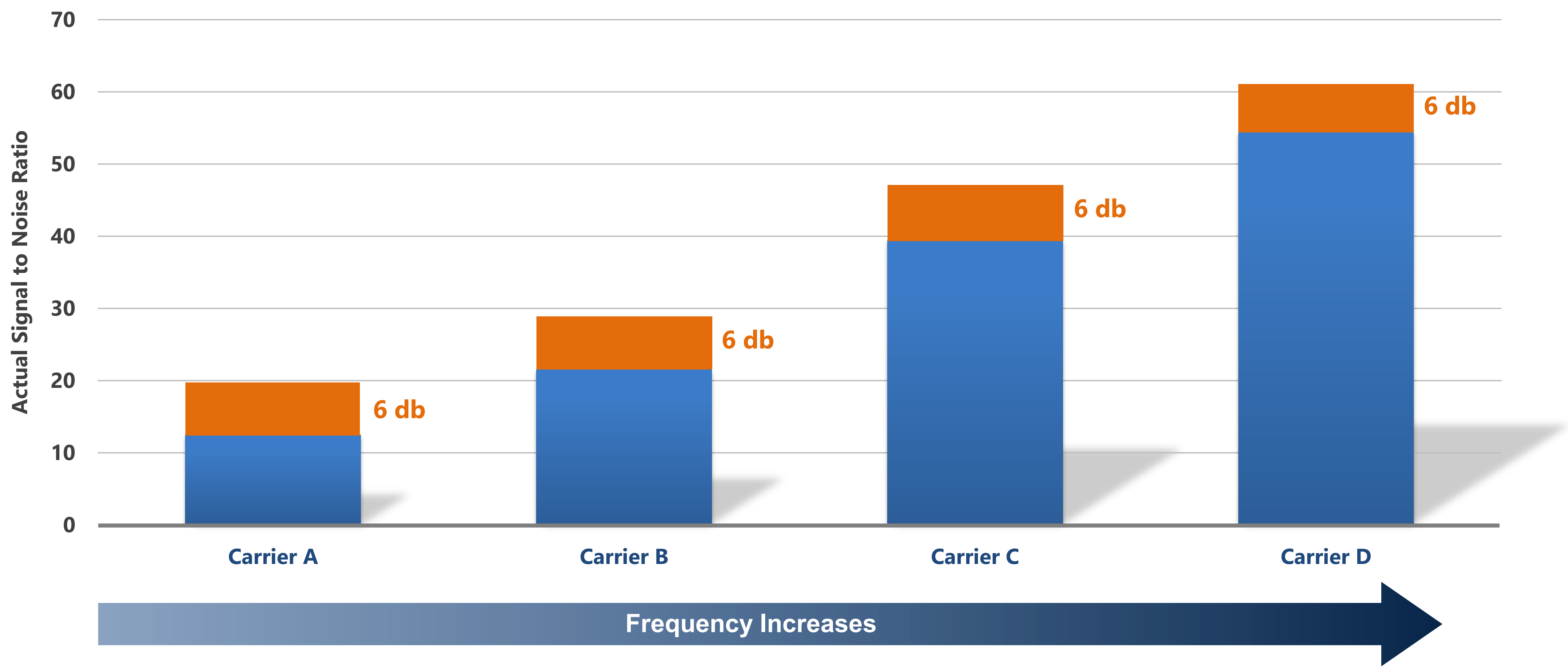
Therefore, there is a tradeoff between the robustness of the channel, such as a phone line, and the achievable data rate. The margin can be used to quantify this tradeoff. A higher margin results in a higher level of immunity to changing channel conditions at the expense of the achievable data rate. Likewise, a lower margin results in a higher data rate at the expense of a lower immunity to changing channel conditions.

Current DMT systems allocate a fixed margin to all subchannels. For example, ADSL systems typically use a 6 dB margin on all subchannels carrying data bits. This 6 dB margin is constant on all subchannels and is independent of the type of impairment that the margin is trying to protect against.

- An SNR Margin is described in the Family 10 patent specification as an extra Signal to Noise Ratio per subchannel, also known as a carrier, in addition to what is required to maintain the specified Bit Error Ratio requirement.

354 Patent at 2:34-45

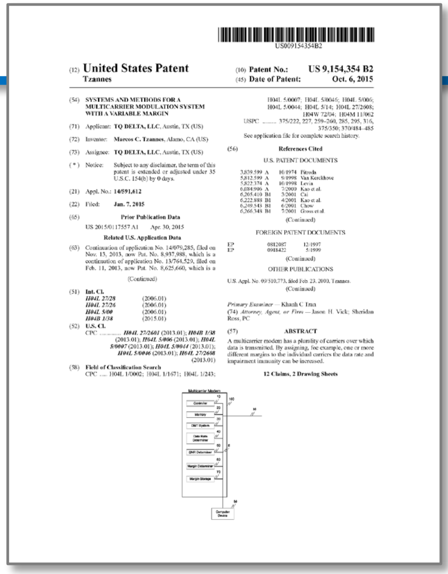
Signal to Noise Ratio Margin (SNR Margin)

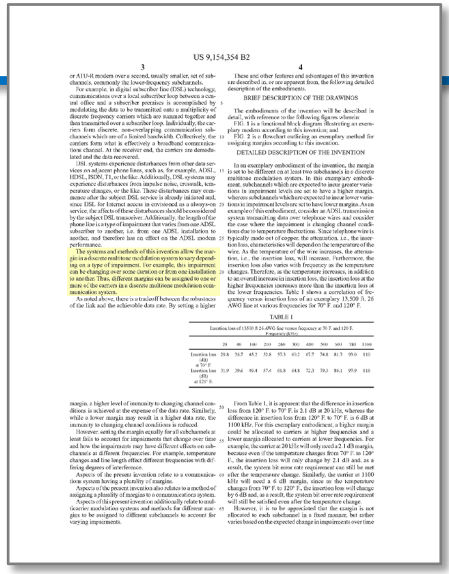


- As an example, the specification describes that ADSL systems typically used a six decibel margin on all carriers carrying bits.

Alleged Solution

> The systems and methods of this invention allow the margin in a discrete multitone modulation system to vary depending on a type of impairment. For example, this impairment can be changing over some duration or from one installation to another. Thus, different margins can be assigned to one or more of the carriers in a discrete multitone modulation communication system.





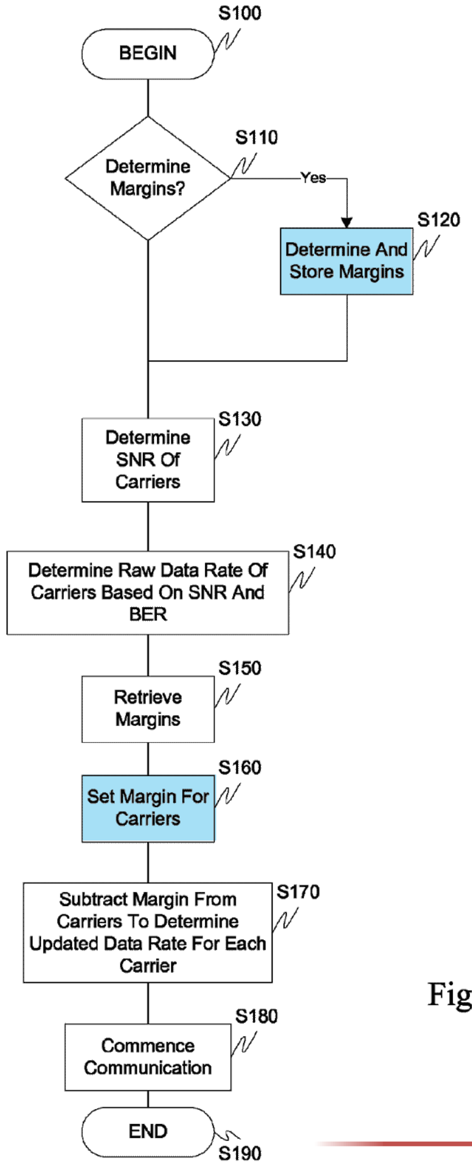
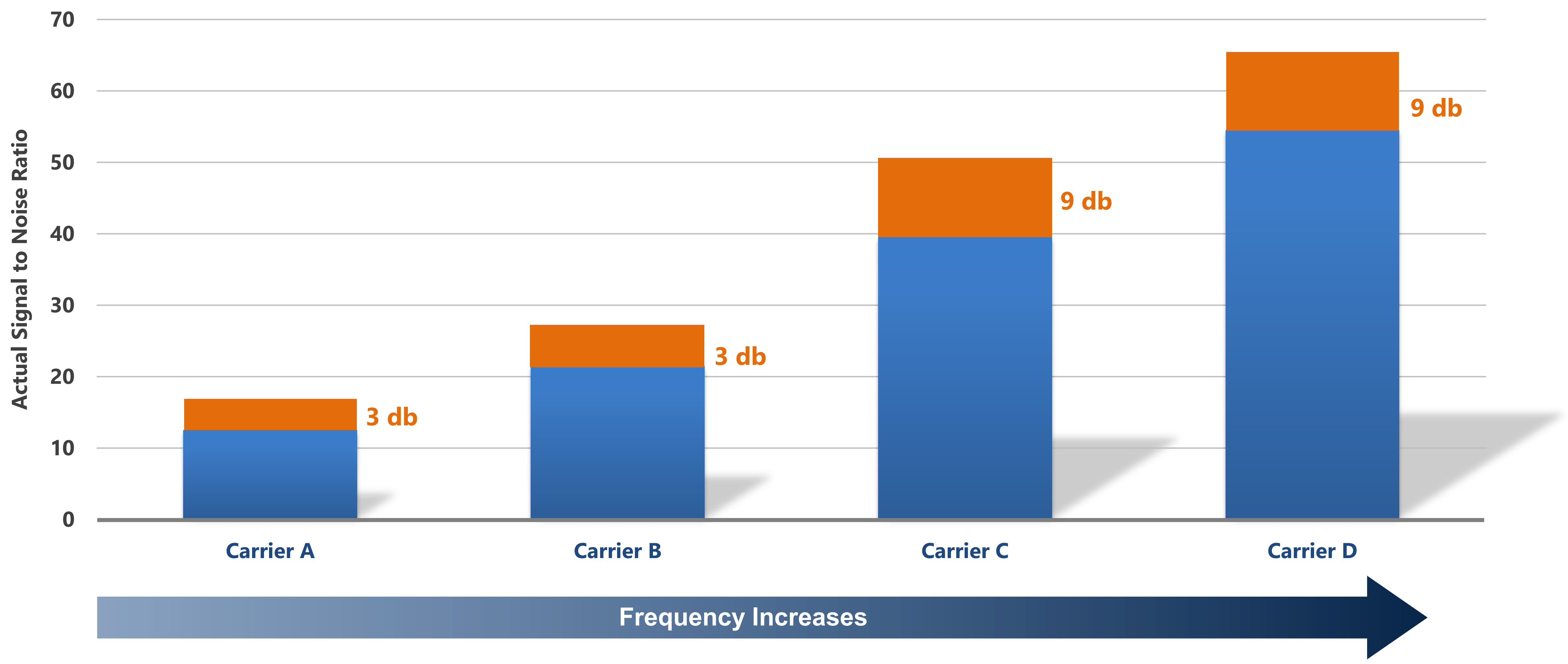


Fig. 2

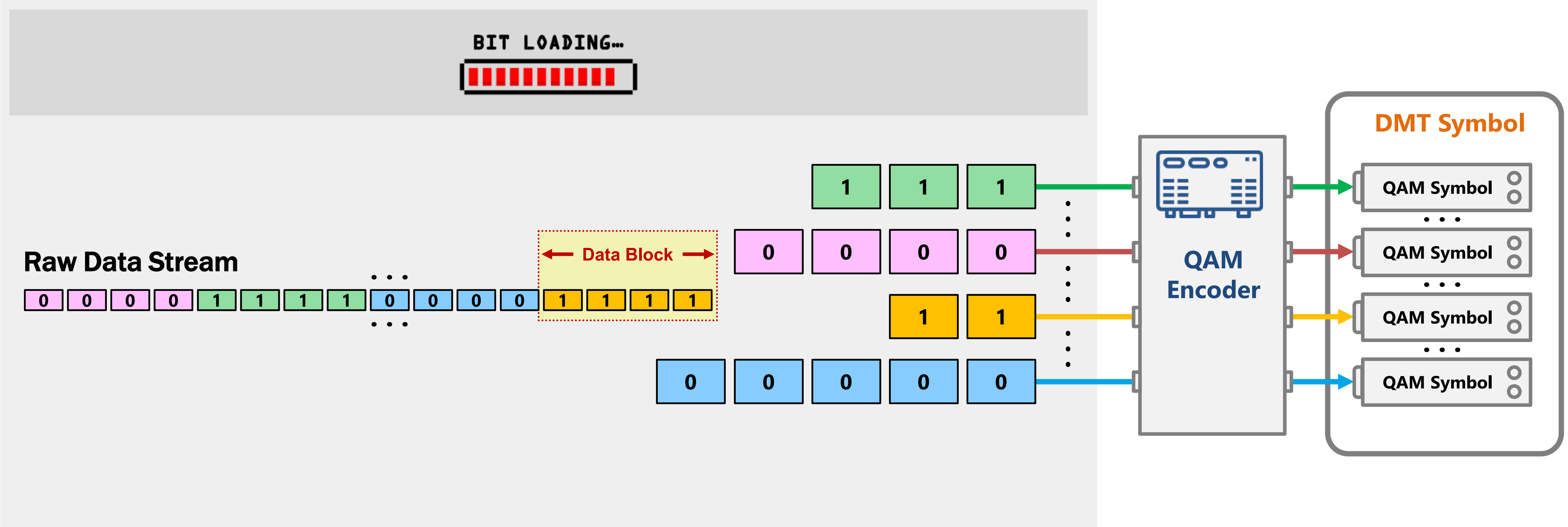
- The Family 10 patents are directed to assigning different margins on one or more of the carriers in a DMT system.

Signal to Noise Ratio Margin (SNR Margin)



- As illustrated on this slide, the Family 10 patents are directed to setting one or more SNR margins on different carriers.

Bit Loading



- The bit loading process begins when a transmitter modulates an input data stream containing information bits with one or more carriers. The DMT transceivers modulate a number of bits on each subchannel or carrier depending on the SNR of that subchannel and BER requirement of a link.

Defendants' Technology Tutorial

TQ Delta v. CommScope, Case No. 2:21-cv-310-JRG (lead)

TQ Delta v. Nokia, Case No. 2:21-cv-309-JRG (member)